Package ‘rstan’

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Title R Interface to Stan
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Description User-facing R functions are provided to parse, compile, test, estimate, and analyze Stan models by accessing the header-only Stan library provided by the 'StanHeaders' package. The Stan project develops a probabilistic programming language that implements full Bayesian statistical inference via Markov Chain Monte Carlo, rough Bayesian inference via 'variational' approximation, and (optionally penalized) maximum likelihood estimation via optimization. In all three cases, automatic differentiation is used to quickly and accurately evaluate gradients without burdening the user with the need to derive the partial derivatives.

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Author Jiqiang Guo [aut], Jonah Gabry [aut], Ben Goodrich [cre, aut], Daniel Lee [ctb].
R topics documented:

Krzysztof Sakrejda [ctb],
Trustees of Columbia University [cph],
Oleg Sklyar [cph] (R/cxxfunplus.R),
The R Core Team [cph] (R/pairs.R, R/dynGet.R),
Jens Oehlschlaegel-Akiyoshi [cph] (R/pairs.R),
Hadley Wickham [cph] (R/rtools.R),
Joel de Guzman [cph] (Boost),
John Fletcher [cph] (Boost),
Thomas Heller [cph] (Boost),
Eric Niebler [cph] (Boost)

Maintainer Ben Goodrich <benjamin.goodrich@columbia.edu>

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R topics documented:

rstan-package .................................................. 3
as.array ....................................................... 5
As.mcmc.list .................................................. 6
Diagnostic plots ............................................... 7
expose_stan_functions ....................................... 9
extract ......................................................... 10
extract_sparse_parts ......................................... 13
log_prob-methods ............................................. 14
lookup ........................................................ 16
makeconf_path ................................................. 17
monitor ......................................................... 18
optimizing .................................................... 19
pairs.stanfit .................................................. 22
plot-methods ................................................... 24
Plots .......................................................... 25
print .......................................................... 28
read_rdump ..................................................... 29
read_stan_csv ................................................ 30
rstan-plotting-functions ...................................... 31
rstan.package.skeleton ....................................... 31
rstan_gg_options ............................................. 32
rstan_options .................................................. 32
sampling ....................................................... 33
set_cppr ......................................................... 36
sflist2stanfit ................................................. 36
stan .......................................................... 38
stanc .......................................................... 45
stanfit-class .................................................. 48
stanmodel-class ............................................... 52
stan_demo ..................................................... 53
stan_model ..................................................... 54
RStan — R interface to Stan

Description

RStan is the R interface to the Stan C++ package. RStan provides

- full Bayesian inference using the No-U-Turn sampler (NUTS), a variant of Hamiltonian Monte Carlo (HMC)
- approximate Bayesian inference using automatic differentiation variational inference (ADVI)
- penalized maximum likelihood estimation using L-BFGS optimization


Other R packages from the Stan Development Team

Various related R packages are also available from the Stan Development Team:

<table>
<thead>
<tr>
<th>Package</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bayesplot</td>
<td>ggplot-based plotting library for graphing parameter estimates, MCMC diagnostics, and posterior predictive checks.</td>
</tr>
<tr>
<td>shinystan</td>
<td>Interactive visual summaries and advanced posterior analysis of MCMC output.</td>
</tr>
<tr>
<td>loo</td>
<td>Out-of-sample predictive performance estimates and model comparison.</td>
</tr>
<tr>
<td>rstanarm</td>
<td>R formula interface for Bayesian applied regression modeling.</td>
</tr>
<tr>
<td>rstantools</td>
<td>Tools for developers of R packages interfacing with Stan.</td>
</tr>
</tbody>
</table>

Author(s)

Authors:  
Jiqiang Guo <guojq28@gmail.com>
Ben Goodrich <benjamin.goodrich@columbia.edu>
Jonah Gabry <jsg2201@columbia.edu>

Maintainer: Ben Goodrich <benjamin.goodrich@columbia.edu>
See Also

- `stan` for details on fitting models and `stanfit` for information on the fitted model objects.
- [https://github.com/stan-dev/rstan/issues/](https://github.com/stan-dev/rstan/issues/) to submit a bug report or feature request.
- [https://groups.google.com/forum/#!forum/stan-users/](https://groups.google.com/forum/#!forum/stan-users/) to ask a question on the Stan-users forum.

Examples

```r
### Not run:

stanmodelcode <- "
data {
  int<lower=0> N;
  real y[N];
}

parameters {
  real mu;
}

model {
  target += normal_lpdf(mu | 0, 10);
  target += normal_lpdf(y | mu, 1);
}
"

y <- rnorm(20)
dat <- list(N = 20, y = y);
fit <- stan(model_code = stanmodelcode, model_name = "example",
           data = dat, iter = 2012, chains = 3, sample_file = 'norm.csv',
           verbose = TRUE)
print(fit)
traceplot(fit)

# extract samples
e <- extract(fit, permuted = TRUE) # return a list of arrays
mu <- e$mu

m <- extract(fit, permuted = FALSE, inc_warmup = FALSE) # return an array
print(dimnames(m))

# using as.array directly on stanfit objects
m2 <- as.array(fit)
```

## End(Not run)
as.array

Create array, matrix, or data.frame objects from samples in a stanfit object

Description

The samples (without warmup) included in a `stanfit` object can be coerced to an `array`, `matrix`, or `data.frame`. Methods are also provided for checking and setting names and dimnames.

Usage

```r
## S3 method for class 'stanfit'
as.array(x, ...)
```

```r
## S3 method for class 'stanfit'
as.matrix(x, ...)
```

```r
## S3 method for class 'stanfit'
as.data.frame(x, ...)
```

```r
## S3 method for class 'stanfit'
is.array(x)
```

```r
## S3 method for class 'stanfit'
dim(x)
```

```r
## S3 method for class 'stanfit'
dimnames(x)
```

```r
## S3 method for class 'stanfit'
names(x)
```

```r
## S3 replacement method for class 'stanfit'
names(x) <- value
```

Arguments

- `x` An object of S4 class `stanfit`.
- `...` Additional parameters that can be passed to `extract` for extracting samples from `x`. For now, `pars` is the only additional parameter supported.
- `value` For the names replacement method, a character vector to set/replace the parameter names in `x`.

Details

`as.array` and `as.matrix` can be applied to a `stanfit` object to coerce the samples without warmup to `array` or `matrix`. The `as.data.frame` method first calls `as.matrix` and then coerces this matrix to a `data.frame`.

The array has three named dimensions: iterations, chains, parameters. For `as.matrix`, all chains are combined, leaving a matrix of iterations by parameters.
Value

as.array, as.matrix, and as.data.frame return an array, matrix, and data.frame, respectively. 
dim and dimnames return the dim and dimnames of the array object that could be created, while 
names returns the third element of the dimnames, which are the names of the margins of the posterior 
distribution. The names assignment method allows for assigning more interpretable names to them. 
is.array returns TRUE for stanfit objects that include samples; otherwise FALSE. 
When the stanfit object does not contain samples, empty objects are returned from as.array, 
as.matrix, as.data.frame, dim, dimnames, and names.

See Also

S4 class stanfit and its method extract

Examples

## Not run:
ext_model_code <- ' 
parameters {
  real alpha[2,3];
  real beta[2];
}
model {
  for (i in 1:2) for (j in 1:3)
    alpha[i, j] ~ normal(0, 1);
  for (i in 1:2)
    beta[i] ~ normal(0, 2);
  # beta ~ normal(0, 2) // vectorized version
}
',

## fit the model
fit <- stan(model_code = ex_model_code, chains = 4)
dim(fit)
dimnames(fit)
is.array(fit)
a <- as.array(fit)
m <- as.matrix(fit)
d <- as.data.frame(fit)

## End(Not run)

As.mcmc.list Create an mcmc.list from a stanfit object

Description

Create an mcmc.list (coda) from a stanfit object.
Diagnostic plots

Usage

As.mcmc.list(object, pars, include = TRUE, ...)

Arguments

object object of class "stanfit"
pars optional character vector of parameters to include
include logical scalar indicating whether to include (the default) or exclude the parameters named in pars
... unused

Value

An object of class mcmc.list.

diagnostic plots

RStan Diagnostic plots

Description

Diagnostic plots for HMC and NUTS using ggplot2.

Usage

stan.diag(object, information = c("sample","stepsize","treedepth","divergence"),
chain = 0, ...)
stan.par(object, par, chain = 0, ...)
stan.rhat(object, pars, ...)
stan.ess(object, pars, ...)
stan.mcse(object, pars, ...)

Arguments

object A stanfit or stanreg object.
information The information to be contained in the diagnostic plot.
par,pars The name of a single scalar parameter (par) or one or more parameter names (pars).
chain If chain=0 (the default) all chains are combined. Otherwise the plot for chain is overlaid on the plot for all chains combined.
... For stan.diag and stan.par, optional arguments to arrangeGrob. For stan.rhat, stan.ess, and stan.mcse, optional arguments to stat_bin.
Diagnostic plots

Details

stan_rhat, stan_ess, stan_mcse Respectively, these plots show the distribution of the Rhat statistic, the ratio of effective sample size to total sample size, and the ratio of Monte Carlo standard error to posterior standard deviation for the estimated parameters. These plots are not intended to identify individual parameters, but rather to allow for quickly identifying if the estimated values of these quantities are desirable for all parameters.

stan_par Calling stan_par generates three plots: (i) a scatterplot of par vs. the accumulated log-posterior (lp__), (ii) a scatterplot of par vs. the average Metropolis acceptance rate (accept_stat), and (iii) a violin plot showing the distribution of par at each of the sampled step sizes (one per chain). For the scatterplots, red points are superimposed to indicate which (if any) iterations encountered a divergent transition. Yellow points indicate a transition that hit the maximum treedepth rather than terminated its evolution normally.

stan_diag The information argument is used to specify which plots stan_diag should generate:

- information='sample' Histograms of lp__ and accept_stat, as well as a scatterplot showing their joint distribution.
- information='stepsizes' Violin plots showing the distributions of lp__ and accept_stat at each of the sampled step sizes (one per chain).
- information='treedepth' Histogram of treedepth and violin plots showing the distributions of lp__ and accept_stat for each value of treedepth.
- information='divergence' Violin plots showing the distributions of lp__ and accept_stat for iterations that encountered divergent transitions (divergent=1) and those that did not (divergent=0).

Value

For stan_diag and stan_par, a list containing the ggplot objects for each of the displayed plots. For stan_rhat, stan_ess, and stan_mcse, a single ggplot object.

Note


See Also

List of RStan plotting functions, Plot options

Examples

```r
## Not run:
fit <- stan_demo("eight_schools")

stan_diag(fit, info = 'sample') # shows three plots together
samp_info <- stan_diag(fit, info = 'sample') # saves the three plots in a list
samp_info[[3]] # access just the third plot

stan_diag(fit, info = 'sample', chain = 1) # overlay chain 1
```
expose_stan_functions

stan_par(fit, par = "mu")
## End(Not run)

---

**expose_stan_functions**  *Exposé les fonctions définies en Stan à R pour le test et la simulation*

**Description**

Le langage de modélisation Stan permet aux utilisateurs de définir leurs propres fonctions dans un bloc de fonctions au sommet d'un programme Stan. La fonction **expose_stan_functions** utilise la fonction **sourceCpp** pour exporter ces fonctions définies par l'utilisateur à l'environnement spécifié pour le test à l'intérieur de R, ou pour faire des simulations prédictives à posteriori dans R plutôt que dans le bloc de quantités générées d'un programme Stan.

**Usage**

```r
expose_stan_functions(stanmodel, ...)
```

**Arguments**

- **stanmodel**  
  Un **stanmodel** objet, un **stanfit** objet, une liste produite par **stanc** ou le chemin à un programme Stan (.stan file). Dans tous ces cas, le programme Stan sous-jacent doit contenir un bloc de fonctions non-vides.

- **...**  
  Arguments supplémentaires passés à **sourceCpp**.

**Details**

Il existe quelques types spéciaux de fonctions définies en Stan pour lesquels d'autres détails sont pertinents:

- **(P)RNG functions**: Si une fonction définie en Stan est nommée _rng, elle peut utiliser la génération aléatoire Boost utilisée par Stan. Lors de l'exposition de ces fonctions à R, un argument d'entrée `seed` est ajouté à la liste des formels. Ce `seed` argument par défaut vaut 0, mais un entier non-négatif peut être passé comme `seed` à la première fois qu'une fonction définie en Stan nommée _rng est appelée. En d'autres termes, la génération aléatoire Boost est initialisée avec ce `seed` mais il est déclaré avec le mot-clé `static` en C++, ce qui signifie qu'elle ne sera pas réinitialisée par les appels subséquents à une fonction définie en Stan nommée _rng.

- **LP functions**: Si une fonction définie en Stan est nommée _lp, elle peut modifier la probabilité de la logique utilisée par Stan pour évaluer les propositions de Metropolis ou comme fonction d'objectif pour l'optimisation. Lors de l'exposition de ces fonctions à R, un argument `lp__` est ajouté à la liste des formels. Ce `lp__` argument par défaut vaut 0, mais une valeur double peut être passée à cet argument lors de l'appel à R. Une telle fonction définie en Stan peut s'arrêter avec `return target();` ou peut exécuter `print(target());` pour vérifier que la calcul est correct.

**Value**

Les noms des nouvelles fonctions dans **env** sont retournés invisiblement.
See Also

sourceCpp

Examples

```r
mc <-

functions {
  int fibonacci(int x);
  int fibonacci(int x) {
    if (x <= 0) reject("x must be positive");
    return x <= 2 ? 1 : fibonacci(x - 1) + fibonacci(x - 2);
  }
}

cppcode <- stanc(model_code = mc, model_name = "Fibonacci")
## Not run:
expose_stan_functions(cppcode)

## End(Not run)
```

---

**extract**

Extract samples from a fitted Stan model

**Description**

Extract samples from a fitted model represented by an instance of class `stanfit`.

**Usage**

```r
## S4 method for signature 'stanfit'
extract(object, pars, permuted = TRUE, inc_warmup = FALSE, include = TRUE)
```

**Arguments**

- `object`: An object of class `stanfit`.
- `pars`: An optional character vector providing the parameter names (or other quantity names) of interest. If not specified, all parameters and other quantities are used. The log-posterior with name `lp__` is also included by default.
- `permuted`: A logical scalar indicating whether the draws after the `warmup` period in each chain should be permuted and merged. If `FALSE`, the original order is kept. For each `stanfit` object, the permutation is fixed (i.e., extracting samples a second time will give the same sequence of iterations).
- `inc_warmup`: A logical scalar indicating whether to include the warmup draws. This argument is only relevant if `permuted` is `FALSE`.
- `include`: A logical scalar indicating whether the parameters named in `pars` should be included (`TRUE`) or excluded (`FALSE`).
extract

Value

When permuted = TRUE, this function returns a named list, every element of which is an array representing samples for a parameter with all chains merged together.

When permuted = FALSE, an array is returned; the first dimension is for the iterations, the second for the number of chains, the third for the parameters. Vectors and arrays are expanded to one parameter (a scalar) per cell, with names indicating the third dimension. See the examples (with comments) below. The `monitor` function can be applied to the returned array to obtain a summary (similar to the print method for `stanfit` objects).

Methods

extract signature(object = "stanfit") Extract samples from a fitted model represented by an instance of class `stanfit`.

See Also

S4 class `stanfit`, `as.array.stanfit`, and `monitor`

Examples

```r
## Not run:
ex_model_code <- 'parameters {
  real alpha[2,3];
  real beta[2];
}
model {
  for (i in 1:2) for (j in 1:3)
    alpha[i, j] ~ normal(0, 1);
  for (i in 1:2)
    beta ~ normal(0, 2);
}

## fit the model
fit <- stan(model_code = ex_model_code, chains = 4)

## extract alpha and beta with 'permuted = TRUE'
fit_ss <- extract(fit, permuted = TRUE) # fit_ss is a list
## list fit_ss should have elements with name 'alpha', 'beta', 'lp__'
alpha <- fit_ss$alpha
beta <- fit_ss$beta
## or extract alpha by just specifying pars = 'alpha'
alpha2 <- extract(fit, pars = 'alpha', permuted = TRUE)$alpha
print(identical(alpha, alpha2))

## or extract alpha by excluding beta and lp__
alpha3 <- extract(fit, pars = c('beta', 'lp__'),
  permuted = TRUE, include = FALSE)$alpha
print(identical(alpha, alpha3))
```
### get the samples for alpha[1,1] and beta[2]
alpha_11 <- alpha[, 1, 1]
beta_2 <- beta[, 2]

### extract samples with 'permuted = FALSE'
fit_ss2 <- extract(fit, permuted = FALSE) # fit_ss2 is an array

### the dimensions of fit_ss2 should be
### "# of iterations * # of chains * # of parameters"
dim(fit_ss2)

### since the third dimension of `fit_ss2` indicates
### parameters, the names should be
### alpha[1,1], alpha[2,1], alpha[1,2], alpha[2,2],
### alpha[1,3], alpha[2,3], beta[1], beta[2], and lp_
### 'lp_' (the log-posterior) is always included
### in the samples.
dimnames(fit_ss2)

### End(Not run)

# Create a stanfit object from reading CSV files of samples (saved in rstan # package) generated by function stan for demonstration purpose from model as follows.
#
excode <- 'transformed data {
real y[20];
y[1] <- 0.5796; y[2] <- 0.2276; y[3] <- -0.2959;
y[16] <- 0.9459; y[17] <- -0.382; y[18] <- 0.7619;
y[19] <- 0.1006; y[20] <- -1.7461;
}
parameters {
real mu;
real<lower=0, upper=10> sigma;
vector[2] z[3];
real<lower=0> alpha;
}
model {
y ~ normal(mu, sigma);
for (i in 1:3)
  z[i] ~ normal(0, 1);
alpha ~ exponential(2);
}'

# exfit <- stan(model_code = excode, save_dso = FALSE, iter = 200,
# sample_file = "rstan_doc_ex.csv")
# exfit <- read_stan_csv(dir(system.file('misc', package = 'rstan'),
  pattern='rstan_doc_ex_{{:digit:}}.csv',
extract_sparse_parts

full.names = TRUE))

ee1 <- extract(exfit, permuted = TRUE)
print(names(ee1))

for (name in names(ee1)) {
  cat(name, "\n")
  print(dim(ee1[[name]]))
}

ee2 <- extract(exfit, permuted = FALSE)
print(dim(ee2))
print(dimnames(ee2))

extract_sparse_parts Extract the compressed representation of a sparse matrix

Description

Create a list of vectors that represents a sparse matrix.

Usage

extract_sparse_parts(A)

Arguments

A A matrix or Matrix.

Details

The Stan Math Library has a function called csr_matrix_times_vector, which inputs a matrix in compressed row storage form and a dense vector and returns their product without fillin. To use the csr_matrix_times_vector function with a large sparse matrix, it is optimal in terms of memory to simply pass the three vectors that characterize the compressed row storage form of the matrix to the data block of the Stan program. The extract_sparse_parts function provides a convenient means of obtaining these vectors.

Value

A named list with components

1. w A numeric vector containing the non-zero elements of A.
2. v An integer vector containing the column indices of the non-zero elements of A.
3. u An integer vector indicating where in w a given row’s non-zero values start.
Examples

```r
A <- rbind(
  c(19L, 27L, 0L, 0L),
  c(0L, 0L, 0L, 0L),
  c(0L, 0L, 0L, 52L),
  c(81L, 0L, 95L, 33L)
)
str(extract_sparse_parts(A))
```

log_prob-methods  

Model’s log_prob and grad_log_prob functions

Description

Using model’s log_prob and grad_log_prob take values from the unconstrained space of model parameters and (by default) return values in the same space. Sometimes we need to convert the values of parameters from their support defined in the parameters block (which might be constrained, and for simplicity, we call it the constrained space) to the unconstrained space and vice versa. The constrain_pars and unconstrain_pars functions are used for this purpose.

Usage

```r
## S4 method for signature 'stanfit'
log_prob(object, upars, adjust_transform = TRUE, gradient = FALSE)

## S4 method for signature 'stanfit'
grad_log_prob(object, upars, adjust_transform = TRUE)

## S4 method for signature 'stanfit'
get_num_upars(object)

## S4 method for signature 'stanfit'
constrain_pars(object, pars)

## S4 method for signature 'stanfit'
unconstrain_pars(object, pars)
```

Arguments

- **object**  
  An object of class `stanfit`.

- **pars**  
  An list specifying the values for all parameters on the constrained space.

- **upars**  
  A numeric vector for specifying the values for all parameters on the unconstrained space.
**log_prob-methods**

`adjust_transform` Logical to indicate whether to adjust the log density since Stan transforms parameters to unconstrained space if it is in constrained space. Set to `FALSE` to make the function return the same values as Stan’s `lp__` output.

`gradient` Logical to indicate whether gradients are also computed as well as the log density.

**Details**

Stan requires that parameters be defined along with their support. For example, for a variance parameter, we must define it on the positive real line. But inside Stan’s samplers, all parameters defined on the constrained space are transformed to unconstrained space, so the log density function need be adjusted (i.e., adding the log of the absolute value of the Jacobian determinant). With the transformation, Stan’s samplers work on the unconstrained space and once a new iteration is drawn, Stan transforms the parameters back to their supports. All the transformation are done by Stan without interference from the users. However, when using the log density function for a model exposed to R, we need to be careful. For example, if we are interested in finding the mode of parameters on the constrained space, we then do not need the adjustment. For this reason, the `log_prob` and `grad_log_prob` functions accept an `adjust_transform` argument.

**Value**

`log_prob` returns a value (up to an additive constant) the log posterior. If `gradient` is `TRUE`, the gradients are also returned as an attribute with name `gradient`.

`grad_log_prob` returns a vector of the gradients. Additionally, the vector has an attribute named `log_prob` being the value the same as `log_prob` is called for the input parameters.

`get_num_upars` returns the number of parameters on the unconstrained space.

`constrain_pars` returns a list and `unconstrain_pars` returns a vector.

**Methods**

`log_prob` signature(object = "stanfit") Compute the log posterior (`lp__`) for the model represented by a `stanfit` object. Note that, by default, `log_prob` returns the log posterior in the unconstrained space; set `adjust_transform = FALSE` to make the values match Stan’s output.

`grad_log_prob` signature(object = "stanfit") Compute the gradients for `log_prob` as well as the log posterior. The latter is returned as an attribute.

`get_num_upars` signature(object = "stanfit") Get the number of unconstrained parameters.

`constrain_pars` signature(object = "stanfit") Convert values of the parameter from unconstrained space (given as a vector) to their constrained space (returned as a named list).

`unconstrain_pars` signature(object = "stanfit") Contrary to constrained, convert values of the parameters from constrained to unconstrained space.

**References**

lookup

Look up the Stan function that corresponds to a R function or name.

Description

This function helps to map between R functions and Stan functions.

Usage

lookup(FUN, ReturnType = character())
**Arguments**

**FUN**

A character string naming a R function or a R function for which the (near) equivalent Stan function is sought. If no matching R function is found, FUN is reinterpreted as a *regexp* and matches are sought.

**ReturnType**

A character string of positive length naming a valid return type for a Stan function: int, int[], matrix, real, real[], real[], row_vector, T[], vector, or void. If "ANY" is passed, then the entire data.frame is returned and can be inspected with the View function, for example.

**Value**

Ordinarily, a data.frame with rows equal to the number of partial matches and four columns:

1. **StanFunction** Character string for the Stan function’s name.
2. **Arguments** Character string indicating the arguments to that Stan function.
3. **ReturnType** Character string indicating the return type of that Stan function.
4. **Page** Integer indicating the page of the Stan reference manual where that Stan function is defined.

If there are no matching Stan functions, a character string indicating so is returned.

**References**


**Examples**

```r
lookup(dnorm)  # Stan equivalents for the normal PDF (in log form)
lookup("foo")  # fails
lookup("Student")  # succeeds even though there is no such R function
lookup("poisson")  # every Stan function that starts with poisson
```

---

**makeconf_path**

*Obtain the full path of file Makeconf*

**Description**

Obtain the full path of file Makeconf, in which, for example the flags for compiling C/C++ code are configured.

**Usage**

```r
makeconf_path()
```
Details

The configuration for compiling shared objects using `R CMD SHLIB` are set in file `makeconf`. To change how the C++ code is compiled, modify this file. For RStan, package `inline` compiles the C++ code using `R CMD SHLIB`. To speed up compiled Stan models, increase the optimization level to `-O3` defined in property `CXXFLAGS` in the file `makeconf`. This file may also be modified to specify alternative C++ compilers, such as clang++ or later versions of g++.

Value

An character string for the full path of file `makeconf`.

See Also

`stan`

Examples

```r
makeconf_path()
```

---

### monitor

#### Compute summaries of MCMC draws and monitor convergence

Description

Similar to the print method for `stanfit` objects, but `monitor` takes an array of simulations as its argument rather than a `stanfit` object. For a 3-D array (iterations * chains * parameters) of MCMC draws, `monitor` computes means, standard deviations, quantiles, Monte Carlo standard errors, split R-hats, and effective sample sizes. By default, half of the iterations are considered warmup and are excluded.

Usage

```r
monitor(sims, warmup = floor(dim(sims)[1]/2),
        probs = c(0.025, 0.25, 0.5, 0.75, 0.975),
        digits_summary = 1, print = TRUE, ...)
```

Arguments

- `sims`: A 3-D array (iterations * chains * parameters) of MCMC simulations from any MCMC algorithm.
- `warmup`: The number of warmup iterations to be excluded when computing the summaries. The default is half of the total number of iterations. If `sims` doesn’t include the warmup iterations then `warmup` should be set to zero.
- `probs`: A numeric vector specifying quantiles of interest. The defaults is `c(0.025, 0.25, 0.5, 0.75, 0.975)`.
- `digits_summary`: The number of significant digits to use when printing the summary, defaulting to 1. Applies to the quantities other than the effective sample size, which is always rounded to the nearest integer.
optimizing

print Logical, indicating whether to print the summary after the computations are performed.
...
... Additional arguments passed to the underlying print method.

Value

A 2-D array with rows corresponding to parameters and columns to the summary statistics.

References


See Also

S4 class *stanfit* and particularly its *print* method.

Examples

csvfiles <- dir(system.file('misc', package = 'rstan'),
    pattern = 'rstan_doc_ex_[0-9].csv', full.names = TRUE)
fit <- read_stan_csv(csvfiles)
# The following is just for the purpose of giving an example
# since print can be used for a stanfit object.
monitor(extract(fit, permuted = FALSE, inc_warmup = TRUE))

---

**optimizing**

*Obtain a point estimate by maximizing the joint posterior*

---

**Description**

Obtain a point estimate by maximizing the joint posterior from the model defined by class *stanmodel*.

**Usage**

```r
## S4 method for signature 'stanmodel'
optimizing(object, data = list(),
    seed = sample.int(.Machine$integer.max, 1), init = 'random',
    check_data = TRUE, sample_file = NULL,
    algorithm = c("LBFGS", "BFGS", "Newton"),
    verbose = FALSE, hessian = FALSE, as_vector = TRUE,
    draws = 0, constrained = TRUE, ...)
```
Arguments

object  An object of class \texttt{stanmodel}.
data  A named list or environment providing the data for the model or a character vector for all the names of objects used as data. See the Note section in \texttt{stan}.
seed  The seed for random number generation. The default is generated from 1 to the maximum integer supported by \texttt{R} on the machine. Even if multiple chains are used, only one seed is needed, with other chains having seeds derived from that of the first chain to avoid dependent samples. When a seed is specified by a number, \texttt{as.integer} will be applied to it. If \texttt{as.integer} produces \texttt{NA}, the seed is generated randomly. The seed can also be specified as a character string of digits, such as "12345", which is converted to integer.
init  Initial values specification. See the detailed documentation for the init argument in \texttt{stan}.
check_data  Logical, defaulting to \texttt{TRUE}. If \texttt{TRUE} the data will be preprocessed; otherwise not. See the Note section in \texttt{stan}.
sample_file  A character string of file name for specifying where to write samples for all parameters and other saved quantities. If not provided, files are not created. When the folder specified is not writable, \texttt{tempdir()} is used.
algorithm  One of "Newton", "BFGS", and "LBFGS" (the default) indicating which optimization algorithm to use.
verbose  \texttt{TRUE} or \texttt{FALSE} (the default): flag indicating whether to print intermediate output from Stan on the console, which might be helpful for model debugging.
hessian  \texttt{TRUE} or \texttt{FALSE} (the default): flag indicating whether to calculate the Hessian (via numeric differentiation of the gradient function in the unconstrained parameter space).
as_vector  \texttt{TRUE} (the default) or \texttt{FALSE}; flag indicating whether a vector is used to store the point estimate found. A list can be used instead by specifying it to be \texttt{FALSE}.
draws  A non-negative integer (that defaults to zero) indicating how many times to draw from a multivariate normal distribution whose parameters are the mean vector and the inverse negative Hessian in the unconstrained space.
constrained  A logical scalar indicating, if \texttt{draws} > 0, whether the draws should be transformed to the constrained space defined in the parameters block of the Stan program. Defaults to \texttt{TRUE}.

\ldots

Other optional parameters:

- \texttt{iter} (integer), the maximum number of iterations, defaulting to 2000.
- \texttt{save_iterations} (logical), a flag indicating whether to save the iterations, defaulting to \texttt{FALSE}.
- \texttt{refresh} (integer), the number of interations between screen updates, defaulting to 100.
- \texttt{init_alpha} (double), for BFGS and LBFGS, the line search step size for first iteration, defaulting to 0.001.
- \texttt{tol_obj} (double), for BFGS and LBFGS, the convergence tolerance on changes in objective function value, defaulting to 1e-12.
optimizing

- `tol_rel_obj` (double), for BFGS and LBFGS, the convergence tolerance on relative changes in objective function value, defaulting to 1e4.
- `tol_grad` (double), for BFGS and LBFGS, the convergence tolerance on the norm of the gradient, defaulting to 1e-8.
- `tol_rel_grad` (double), for BFGS and LBFGS, the convergence tolerance on the relative norm of the gradient, defaulting to 1e7.
- `tol_param` (double), for BFGS and LBFGS, the convergence tolerance on changes in parameter value, defaulting to 1e-8.
- `history_size` (integer), for LBFGS, the number of update vectors to use in Hessian approximations, defaulting to 5.

Refer to the manuals for both CmdStan and Stan for more details.

**Value**

- **par**
  The point estimate found. Its form (vector or list) is determined by the `as_vector` argument.

- **value**
  The value of the log-posterior (up to an additive constant, the "lp__" in Stan) corresponding to `par`.

- **return_code**
  The value of the return code from the optimizer; anything that is not zero is problematic.

- **hessian**
  The Hessian matrix if `hessian` is TRUE

- **theta_tilde**
  If `draws > 0`, the matrix of parameter draws in the constrained or unconstrained space, depending on the value of the `constrained` argument.

- **log_p**
  If `draws > 0`, a vector of length `draws` that contains the value of the log-posterior evaluated at each row of `theta_tilde`.

- **log_g**
  If `draws > 0`, a vector of length `draws` that contains the value of the logarithm of the multivariate normal density evaluated at each row of `theta_tilde`.

If the optimization is not completed for reasons such as feeding wrong data, it returns NULL.

**Methods**

 optimising signature(object = "stanmodel")

Call Stan’s optimization methods to obtain a point estimate for the model defined by S4 class `stanmodel` given the data, initial values, etc.

**See Also**

- `stanmodel`

**Examples**

```r
## Not run:
m <- stan_model(model_code = 'parameters {real y; model {y ~ normal(0,1);}}')
f <- optimising(m, hessian = TRUE)

## End(Not run)
```
pairs.stanfit

Create a matrix of output plots from a stanfit object

Description

A pairs method that is customized for MCMC output

Usage

```r
## S3 method for class 'stanfit'
pairs(x, labels = NULL, panel = NULL, ..., lower.panel = NULL,
      upper.panel = NULL, diag.panel = NULL, text.panel = NULL,
      label.pos = 0.5 + 1/3, cex.labels = NULL, font.labels = 1,
      rowlattop = TRUE, gap = 1, log = "", pars = NULL, condition = "accept_stat__",
      include = TRUE)
```

Arguments

- `x`: An object of S4 class stanfit
- `labels`, `panel`, `...`, `lower.panel`, `upper.panel`, `diag.panel`: Same as in `pairs` syntactically but see the Details section for different default arguments
- `text.panel`, `label.pos`, `cex.labels`, `font.labels`, `rowlattop`, `gap`: Same as in `pairs.default`
- `log`: Same as in `pairs.default`, which makes it possible to utilize logarithmic axes and additionally accepts `log = TRUE`. See the Details section.
- `pars`: If not NULL, a character vector indicating which quantities to include in the plots, which is passed to `extract`. Thus, by default, all unknown quantities are included, which may be far too many to visualize on a small computer screen. If `include = FALSE`, then the named parameters are excluded from the plot.
- `condition`: If NULL, it will plot roughly half of the chains in the lower panel and the rest in the upper panel. An integer vector can be passed to select some subset of the chains, of which roughly half will be plotted in the lower panel and the rest in the upper panel. A list of two integer vectors can be passed, each specifying a subset of the chains to be plotted in the lower and upper panels respectively. A single number between zero and one exclusive can be passed, which is interpreted as the proportion of realizations (among all chains) to plot in the lower panel starting with the first realization in each chain, with the complement (from the end of each chain) plotted in the upper panel. A (possibly abbreviated) character vector of length one can be passed among "accept_stat__", "stepsize__", "treedepth__", "n_leapfrog__", "divergent__", "energy__", or "lp__", which are the variables produced by `get_sampler_params` and `get_logposterior`. In that case the lower panel will plot realizations that are below the median of the indicated variable (or are zero in the case...
of "divergent__") and the upper panel will plot realizations that are greater than or equal to the median of the indicated variable (or are one in the case of "divergent__"). Finally, any logical vector whose length is equal to the product of the number of iterations and the number of chains can be passed, in which case realizations corresponding to FALSE and TRUE will be plotted in the lower and upper panel respectively. The default is "accept_stat__".

include Logical scalar indicating whether to include (the default) or excldue the parameters named in the pars argument from the plot.

Details

This method differs from the default pairs method in the following ways. If unspecified, the smoothScatter function is used for the off-diagonal plots, rather than points, since the former is more appropriate for visualizing thousands of draws from a posterior distribution. Also, if unspecified, histograms of the marginal distribution of each quantity are placed on the diagonal of the plot, after pooling all of the chains specified by the chain_id argument.

The draws from the warmup phase are always discarded before plotting.

By default, the lower (upper) triangle of the plot contains draws with below (above) median acceptance probability. Also, if condition is not "divergent__", red points will be superimposed onto the smoothed density plots indicating which (if any) iterations encountered a divergent transition. Otherwise, yellow points indicate a transition that hit the maximum treedepth rather than terminated its evolution normally.

You may very well want to specify the log argument for non-negative parameters. However, the pairs function will drop (with a message) parameters that are either constant or duplicative with previous parameters. For example, if a correlation matrix is included among pars, then neither its diagonal elements (which are always 1) nor its upper triangular elements (which are the same as the corresponding lower triangular elements) will be included. Thus, if log is an integer vector, it needs to pertain to the parameters after constant and duplicative ones are dropped. It is perhaps easiest to specify log = TRUE, which will utilize logarithmic axes for all non-negative parameters, except lp__ and any integer valued quantities.

See Also

S4 class stanfit and its method extract as well as the pairs generic function. Also, see get_sampler_params and get_logposterior.

Examples

e xample(read_stan_csv)
pairs(fit, pars = c("mu", "sigma", "alpha", "lp__"), log = TRUE, las = 1)
# sigma and alpha will have logarithmic axes
**Description**

The default plot shows posterior uncertainty intervals and point estimates for parameters and generated quantities. The `plot` method can also be used to call the other `rstan` plotting functions via the `plotfun` argument (see Examples).

**Usage**

```r
## S4 method for signature 'stanfit,missing'
plot(x, ..., plotfun)
```

**Arguments**

- `x`: An instance of class `stanfit`.
- `plotfun`: A character string naming the plotting function to apply to the stanfit object. If `plotfun` is missing, the default is to call `stan_plot`, which generates a plot of credible intervals and point estimates. See `rstan-plotting-functions` for the names and descriptions of the other plotting functions. `plotfun` can be either the full name of the plotting function (e.g. "stan_hist") or can be abbreviated to the part of the name following the underscore (e.g. "hist").
- `...`: Optional arguments to `plotfun`.

**Value**

A `ggplot` object that can be further customized using the `ggplot2` package.

**Note**

Because the `rstan` plotting functions use `ggplot2` (and thus the resulting plots behave like `ggplot` objects), when calling a plotting function within a loop or when assigning a plot to a name (e.g., `graph <- plot(fit, plotfun = "rhat"))`, if you also want the side effect of the plot being displayed you must explicitly print it (e.g., `graph <- plot(fit, plotfun = "rhat"))`, `print(graph <- plot(fit, plotfun = "rhat"))`).

**See Also**

- List of RStan plotting functions, Plot options

**Examples**

```r
## Not run:
library(rstan)
fit <- stan_demo("eight_schools")
plot(fit)
plot(fit, show_density = TRUE, ci_level = 0.5, fill_color = "purple")
```
plot(fit, plotfun = "hist", pars = "theta", include = FALSE)
plot(fit, plotfun = "trace", pars = c("mu", "tau"), inc_warmup = TRUE)
plot(fit, plotfun = "rhat") + ggtitle("Example of adding title to plot")

## End(Not run)

---

### Plots

#### ggplot2 for RStan

### Description

Visual posterior analysis using ggplot2.

### Usage

stan_plot(object, pars, include = TRUE, unconstrain = FALSE, ...)
stan_trace(object, pars, include = TRUE, unconstrain = FALSE,
          inc_warmup = FALSE, nrow = NULL, ncol = NULL, ...,
          window = NULL)
stan_scat(object, pars, unconstrain = FALSE,
          inc_warmup = FALSE, nrow = NULL, ncol = NULL, ...)
stan_hist(object, pars, include = TRUE, unconstrain = FALSE,
          inc_warmup = FALSE, nrow = NULL, ncol = NULL, ...)
stan_dens(object, pars, include = TRUE, unconstrain = FALSE,
          inc_warmup = FALSE, nrow = NULL, ncol = NULL, ...,
          separate_chains = FALSE)
stan_ac(object, pars, include = TRUE, unconstrain = FALSE,
          inc_warmup = FALSE, nrow = NULL, ncol = NULL, ...,
          separate_chains = FALSE, lags = 25, partial = FALSE)
quietgg(gg)

### Arguments

- **object**: A stanfit or stanreg object.
- **pars**: Optional character vector of parameter names. If object is a stanfit object, the default is to show all user-defined parameters or the first 10 (if there are more than 10). If object is a stanreg object, the default is to show all (or the first 10) regression coefficients (including the intercept). For stan_scat only, pars should not be missing and should contain exactly two parameter names.
- **include**: Should the parameters given by the pars argument be included (the default) or excluded from the plot?
- **unconstrain**: Should parameters be plotted on the unconstrained space? Defaults to FALSE. Only available if object is a stanfit object.
- **inc_warmup**: Should warmup iterations be included? Defaults to FALSE.
- **nrow, ncol**: Passed to **facet_wrap**.
Optional additional named arguments passed to geoms (e.g. for stan_trace the geom is `geom_path` and we could specify `linetype`, `size`, `alpha`, etc.). For stan_plot there are also additional arguments that can be specified in ... (see Details).

**window**
For `stan_trace` window is used to control which iterations are shown in the plot. See `traceplot`.

**separate_chains**
For `stan_dens`, should the density for each chain be plotted? The default is `FALSE`, which means that for each parameter the draws from all chains are combined. For `stan_ac`, if `separate_chains=FALSE` (the default), the autocorrelation is averaged over the chains. If `TRUE` each chain is plotted separately.

**lags**
For `stan_ac`, the maximum number of lags to show.

**partial**
For `stan_ac`, should partial autocorrelations be plotted instead? Defaults to `FALSE`.

**gg**
A `ggplot` object or an expression that creates one.

### Details

For `stan_plot`, there are additional arguments that can be specified in ... The optional arguments and their default values are:

- `point_est = "median"` The point estimate to show. Either "median" or "mean".
- `show_density = FALSE` Should kernel density estimates be plotted above the intervals?
- `ci_level = 0.8` The posterior uncertainty interval to highlight. Central 100*`ci_level`% intervals are computed from the quantiles of the posterior draws.
- `outer_level = 0.95` An outer interval to also draw as a line (if `show_outer_line` is `TRUE`) but not highlight.
- `show_outer_line = TRUE` Should the `outer_level` interval be shown or hidden? Defaults to `TRUE` (to plot it).
- `fill_color, outline_color, est_color` Colors to override the defaults for the highlighted interval, the outer interval (and density outline), and the point estimate.

### Value

A `ggplot` object that can be further customized using the `ggplot2` package.

### Note

Because the `rstan` plotting functions use `ggplot2` (and thus the resulting plots behave like `ggplot` objects), when calling a plotting function within a loop or when assigning a plot to a name (e.g., `graph <- plot(fit, plotfun = "rhat")`), if you also want the side effect of the plot being displayed you must explicitly print it (e.g., `(graph <- plot(fit, plotfun = "rhat")), print(graph <- plot(fit, plotfun = "rhat")))`.

### See Also

- List of RStan plotting functions
- Plot options
Examples

```r
## Not run:
example("read_stan_csv")
stan_plot(fit)
stan_trace(fit)

library(gridExtra)
fit <- stan_demo("eight_schools")

stan_plot(fit)
stan_plot(fit, point_est = "mean", show_density = TRUE, fill_color = "maroon")

# histograms
stan_hist(fit)
# suppress ggplot2 messages about default bindwidth
quietgg(stan_hist(fit))
quietgg(h <- stan_hist(fit, pars = "theta", binwidth = 5))

# juxtapose histograms of tau and unconstrained tau
tau <- stan_hist(fit, pars = "tau")
tau_unc <- stan_hist(fit, pars = "tau", unconstrain = TRUE) +
  xlab("tau unconstrained")
gird.arrange(tau, tau_unc)

# kernel density estimates
stan_dens(fit)
(dens <- stan_dens(fit, fill = "skyblue", ))
dens <- dens + ggtitle("Kernel Density Estimates\n") + xlab(""")
dens

(dens_sep <- stan_dens(fit, separate_chains = TRUE, alpha = 0.3))
dens_sep + scale_fill_manual(values = c("red", "blue", "green", "black"))
(dens_sep_stack <- stan_dens(fit, pars = "theta", alpha = 0.5,
  separate_chains = TRUE, position = "stack"))

# traceplot
trace <- stan_trace(fit)
trace +
  scale_color_manual(values = c("red", "blue", "green", "black"))
trace +
  scale_color_brewer(type = "div") +
  theme(legend.position = "none")

facet_style <- theme(strip.background = element_rect(fill = "white"),
  strip.text = element_text(size = 13, color = "black"))
(trace <- trace + facet_style)

# scatterplot
(mu_vs_tau <- stan_scat(fit, pars = c("mu", "tau"), color = "blue", size = 4))
mu_vs_tau +
  coord_flip()
```
print(x, pars = x@sim$pars oi, probs = c(0.025, 0.25, 0.5, 0.75, 0.975), digits_summary = 2, include = TRUE, ...)
read_rdump

See Also

S4 class stanfit and particularly its method summary, which is used to obtain the values that are printed.

read_rdump

Read data in an R dump file to a list

Description

Create an R list from an R dump file

Usage

read_rdump(f, keep.source = FALSE, ...)

Arguments

f A character string providing the dump file name.
keep.source logical: should the source formatting be retained when echoing expressions, if possible?
... passed to source

Details

The R dump file can be read directly by R function source, which by default would read the data into the user's workspace (the global environment). This function instead read the data to a list, making it convenient to prepare data for the stan model-fitting function.

Value

A list containing all the data defined in the dump file with keys corresponding to variable names.

See Also

stan_rdump; dump

Examples

x <- 1; y <- 1:10; z <- array(1:10, dim = c(2,5))
stan_rdump(ls(pattern = "^[xyz]"), "xyz.Rdump")
l <- read_rdump('xyz.Rdump')
print(l)
read_stan_csv  

Read CSV files of samples generated by (R)Stan into a stanfit object

Description

Create a stanfit object from the saved CSV files that are created by Stan or RStan and that include the samples drawn from the distribution of interest to facilitate analysis of samples using RStan.

Usage

read_stan_csv(csvfiles, col_major = TRUE)

Arguments

csvfiles   A character vector providing CSV file names
col_major  The order for array parameters; default to TRUE

Details

Stan and RStan could save the samples to CSV files. This function reads the samples and using the comments (beginning with "#") to create a stanfit object. The model name is derived from the first CSV file.

col_major specifies how array parameters are ordered in each row of the CSV files. For example, parameter "a[2,2]" would be ordered as "a[1,1], a[2,1], a[1,2], a[2,2]" if col_major is TRUE.

Value

A stanfit object (with invalid stanmodel slot). This stanfit object cannot be used to re-run the sampler.

See Also

stanfit

Examples

csvfiles <- dir(system.file('misc', package = 'rstan'),
               pattern = 'rstan_doc_ex_[0-9].csv', full.names = TRUE)
fit <- read_stan_csv(csvfiles)
rstan-plotting-functions

RStan Plotting Functions

Description

List of RStan plotting functions that return ggplot objects

RStan plotting functions

- Posterior intervals and point estimates: \texttt{stan_plot}
- Traceplots: \texttt{stan_trace}
- Histograms: \texttt{stan_hist}
- Kernel density estimates: \texttt{stan_dens}
- Scatterplots: \texttt{stan_scat}
- Diagnostics for Hamiltonian Monte Carlo and the No-U-Turn Sampler: \texttt{stan_diag}
- Rhat: \texttt{stan_rhat}
- Ratio of effective sample size to total posterior sample size: \texttt{stan_ess}
- Ratio of Monte Carlo standard error to posterior standard deviation: \texttt{stan_mcse}
- Autocorrelation: \texttt{stan_ac}

See Also

- Plot options

rstan.package.skeleton

Create a Skeleton for a New Source Package with Stan Programs

Description

This function has been removed from \texttt{rstan}. Please use the new \texttt{rstan_package_skeleton} function in the \texttt{rstantools} package.
rstan_gg_options  Set default appearance options

Description

Set default appearance options

Usage

rstan_gg_options(…)

rstan_ggtheme_options(…)

Arguments

…

For rstan_ggtheme_options, see theme for the theme elements that can be specified in .... For rstan_gg_options, ... can be fill, color, chain_colors, size, pt_color, or pt_size. See Examples.

See Also

List of RStan plotting functions

Examples

rstan_ggtheme_options(panel.background = element_rect(fill = "gray"),
                      legend.position = "top")

rstan_gg_options(fill = "skyblue", color = "skyblue4", pt_color = "red")

rstan_options  Set and read options used in RStan

Description

Set and read options used in RStan. Some settings as options can be controlled by the user.

Usage

rstan_options(…)

Arguments

…

Arguments of the form opt = val set option opt to value val. Arguments of the form opt set the function to return option opt’s value. Each argument must be a character string.
**Details**

The available options are:

1. `plot_rhat_breaks`: The cut off points for Rhat for which we would indicate using a different color. This is a numeric vector, defaulting to `c(1.1, 1.2, 1.5, 2)`. The value for this option will be sorted in ascending order, so for example `plot_rhat_breaks = c(1.2, 1.5)` is equivalent to `plot_rhat_breaks = c(1.5, 1.2)`.

2. `plot_rhat_cols`: A vector of the same length as `plot_rhat_breaks` that indicates the colors for the breaks.

3. `plot_rhat_nan_col`: The color for Rhat when it is Inf or NaN.

4. `plot_rhat_large_col`: The color for Rhat when it is larger than the largest value of `plot_rhat_breaks`.

5. `rstan_alert_col`: The color used in method plot of S4 class `stanfit` to show that the vector/array parameters are truncated.

6. `rstan_chain_cols`: The colors used in methods `plot` and `traceplot` of S4 class `stanfit` for coloring different chains.

7. `rstan_warmup_bg_col`: The background color for the warmup area in the traceplots.

8. `boost_lib`: The path for the Boost C++ library used to compile Stan models. This option is valid for the whole R session if not changed again.

9. `eigen_lib`: The path for the Eigen C++ library used to compile Stan models. This option is valid for the whole R session if not changed again.

10. `auto_write`: A logical scalar (defaulting to `false`) that controls whether a compiled instance of a `stanmodel-class` is written to the hard disk in the same directory as the .stan program.

**Value**

The values as a list for existing options and NA for non-existent options. When only one option is specified, its old value is returned.

---

**sampling**

Draw samples from a Stan model

**Description**

Draw samples from the model defined by class `stanmodel`.

**Usage**

```r
## S4 method for signature 'stanmodel'
sampling(object, data = list(), pars = NA,
  chains = 4, iter = 2000, warmup = floor(iter/2), thin = 1,
  seed = sample.int(.Machine$integer.max, 1),
  init = 'random', check_data = TRUE,
  sample_file = NULL, diagnostic_file = NULL, verbose = FALSE,
```
algorithm = c("NUTS", "HMC", "Fixed_param"),
control = NULLL, include = TRUE,
cores = getOption("mc.cores", 1L),
open_progress = interactive() && !isatty(stdout()) && !identical(Sys.getenv("RSTUDIO"), "1"),
show_messages = TRUE, ...)

Arguments

object
An object of class stanmodel.

data
A named list or environment providing the data for the model or a character vector for all the names of objects used as data. See the Note section in stan.

pars
A vector of character strings specifying parameters of interest. The default is NA indicating all parameters in the model. If include = TRUE, only samples for parameters named in pars are stored in the fitted results. Conversely, if include = FALSE, samples for all parameters except those named in pars are stored in the fitted results.

chains
A positive integer specifying the number of Markov chains. The default is 4.

iter
A positive integer specifying the number of iterations for each chain (including warmup). The default is 2000.

warmup
A positive integer specifying the number of warmup (aka burnin) iterations per chain. If step-size adaptation is on (which it is by default), this also controls the number of iterations for which adaptation is run (and hence these warmup samples should not be used for inference). The number of warmup iterations should not be larger than iter and the default is iter/2.

thin
A positive integer specifying the period for saving samples. The default is 1, which is usually the recommended value.

seed
The seed for random number generation. The default is generated from 1 to the maximum integer supported by R on the machine. Even if multiple chains are used, only one seed is needed, with other chains having seeds derived from that of the first chain to avoid dependent samples. When a seed is specified by a number, as.integer will be applied to it. If as.integer produces NA, the seed is generated randomly. The seed can also be specified as a character string of digits, such as "12345", which is converted to integer.

init
Initial values specification. See the detailed documentation for the init argument in stan.

check_data
Logical, defaulting to TRUE. If TRUE the data will be preprocessed; otherwise not. See the Note section in stan.

sample_file
An optional character string providing the name of a file. If specified the draws for all parameters and other saved quantities will be written to the file. If not provided, files are not created. When the folder specified is not writable, tempdir() is used. When there are multiple chains, an underscore and chain number are appended to the file name prior to the .csv extension.

diagnostic_file
An optional character string providing the name of a file. If specified the diagnostics data for all parameters will be written to the file. If not provided, files
are not created. When the folder specified is not writable, `tempdir()` is used. When there are multiple chains, an underscore and chain number are appended to the file name prior to the `.csv` extension.

**verbose**

TRUE or FALSE: flag indicating whether to print intermediate output from Stan on the console, which might be helpful for model debugging.

**algorithm**

One of sampling algorithms that are implemented in Stan. Current options are "NUTS" (No-U-Turn sampler, Hoffman and Gelman 2011, Betancourt 2017), "HMC" (static HMC), or "Fixed_param". The default and preferred algorithm is "NUTS".

**control**

A named list of parameters to control the sampler’s behavior. See the details in the documentation for the control argument in `stan`.

**include**

Logical scalar defaulting to TRUE indicating whether to include or exclude the parameters given by the `pars` argument. If FALSE, only entire multidimensional parameters can be excluded, rather than particular elements of them.

**cores**

Number of cores to use when executing the chains in parallel, which defaults to 1 but we recommend setting the `mc.cores` option to be as many processors as the hardware and RAM allow (up to the number of chains).

**open_progress**

Logical scalar that only takes effect if `cores` > 1 but is recommended to be TRUE in interactive use so that the progress of the chains will be redirected to a file that is automatically opened for inspection. For very short runs, the user might prefer FALSE.

**show_messages**

Either a logical scalar (defaulting to TRUE) indicating whether to print the summary of Informational Messages to the screen after a chain is finished or a character string naming a path where the summary is stored. Setting to FALSE is not recommended unless you are very sure that the model is correct up to numerical error.

Additional arguments can be `chain_id`, `init_r`, `test_grad`, `append_samples`, `refresh`, `enable_random_init`. See the documentation in `stan`.

**Value**

An object of S4 class `stanfit` representing the fitted results. Slot `mode` for this object indicates if the sampling is done or not.

**Methods**

`sampling signature(object = "stanmodel")`

Call a sampler (NUTS, HMC, or Fixed_param depending on parameters) to draw samples from the model defined by S4 class `stanmodel` given the data, initial values, etc.

**See Also**

`stanmodel`, `stanfit`, `stan`
Examples

```r
## Not run:
m <- stan_model(model_code = 'parameters {real y;} model {y ~ normal(0,1);}')
f <- sampling(m, iter = 100)
## End(Not run)
```

---

**set_cppo**

*Defunct function to set the compiler optimization level*

Description

This function returns nothing and does nothing except throw a warning. See [https://cran.r-project.org/doc/manuals/r-release/R-admin.html#Customizing-package-compilation](https://cran.r-project.org/doc/manuals/r-release/R-admin.html#Customizing-package-compilation) for information on customizing the compiler options, but doing so should be unnecessary for normal usage.

Usage

```r
set_cppo(...) 
```

Arguments

`...` Any input is ignored

Value

An invisible NULL

---

**sflist2stanfit**

*Merge a list of stanfit objects into one*

Description

This function takes a list of stanfit objects and returns a consolidated stanfit object. The stanfit objects to be merged need to have the same configuration of iteration, warmup, and thin, besides being from the same model. This could facilitate some parallel usage of RStan. For example, if we call `stan` by parallel and it returns a list of stanfit objects, this function can be used to create one stanfit object from the list.

Usage

```r
sflist2stanfit(sflist)
```
Arguments

sflist A list of stanfit objects.

Value

An S4 object of stanfit consolidated from all the input stanfit objects.

Note

This function should be called in rare circumstances because sampling has a cores argument that allows multiple chains to be executed in parallel. However, if you need to depart from that, the best practice is to use sflist2stanfit on a list of stanfit objects created with the same seed but different chain_id (see example below). Using the same seed but different chain_id can make sure the random number generations for all chains are not correlated.

This function would do some check to see if the stanfit objects in the input list can be merged. But the check is not sufficient. So generally, it is the user's responsibility to make sure the input is correct so that the merging makes sense.

The date in the new stanfit object is when it is merged.

get_seed function for the new consolidated stanfit object only returns the seed used in the first chain of the new object.

The sampler such as NUTS2 that is displayed in the printout by print is the sampler used for the first chain. The print method assumes the samplers are the same for all chains.

The included stanmodel object, which includes the compiled model, in the new stanfit object is from the first element of the input list.

References


See Also

stan

Examples

```r
## Not run:
library(rstan)
scode <- "
data {
  int<lower=1> N;
}
parameters {
  real y1[N];
  real y2[N];
}
model {
  y1 ~ normal(0, 1);
```
y2 ~ double_exponential(0, 2);
}

seed <- 123 # or any other integer
foo_data <- list(N = 2)
foo <- stan(model_code = scode, data = foo_data, chains = 1, iter = 1)
f1 <- stan(fit = foo, data = foo_data, chains = 1, seed = seed, chain_id = 1)
f2 <- stan(fit = foo, data = foo_data, chains = 2, seed = seed, chain_id = 2:3)
f12 <- sflist2stanfit(list(f1, f2))

## parallel stan call for unix-like OS
library(parallel)

if (.Platform$OS.type == "unix") {
  sflist1 <-
    mclapply(1:4, mc.cores = 2,
      function(i) stan(fit = foo, data = foo_data, seed = seed,
            chains = 1, chain_id = i, refresh = -1)
  f3 <- sflist2stanfit(sflist1)
}

if (.Platform$OS.type == "windows") { # also works on non-Windows
  CL <- makeCluster(2)
  clusterExport(cl = CL, c("foo_data", "foo", "seed"))
  sflist1 <- parLapply(CL, 1:4, fun = function(cid) {
    require(rstan)
    stan(fit = foo, data = foo_data, chains = 1,
      iter = 2000, seed = seed, chain_id = cid)
  })
  fit <- sflist2stanfit(sflist1)
  print(fit)
  stopCluster(CL)
} # end example for Windows

## End(Not run)

---

### Description

Fit a model defined in the Stan modeling language and return the fitted result as an instance of `stanfit`.

### Usage

```
stan(file, model_name = "anon_model", model_code = "",
    fit = NA, data = list(), pars = NA, chains = 4,
    iter = 2000, warmup = floor(iter/2), thin = 1,
    init = "random", seed = sample.int(.Machine$integer.max, 1),
```
algorithm = c("NUTS", "HMC", "Fixed_param"),
control = NULL,
sample_file = NULL, diagnostic_file = NULL,
save_dso = TRUE,
verbose = FALSE, include = TRUE,
cores = getOption("mc.cores", 1L),
open_progress = interactive() && !isatty(stdout()) &&
    !identical(Sys.getenv("RSTUDIO"), "1"),

...,
boost_lib = NULL,
eigen_lib = NULL)

Arguments

file A character string file name or a connection that R supports containing the text of a model specification in the Stan modeling language; a model may also be specified directly as a character string using parameter model_code or through a previous fit using parameter fit. When fit is specified, parameter file is ignored.

model_name A character string naming the model; defaults to "anon_model". However, the model name would be derived from file or model_code (if model_code is the name of a character string object) if model_name is not specified.

model_code A character string either containing the model definition or the name of a character string object in the workspace. This parameter is used only if parameter file is not specified. When fit is specified, the model compiled previously is used so specifying model_code is ignored.

fit An instance of S4 class stanfit derived from a previous fit; defaults to NA. If fit is not NA, the compiled model associated with the fitted result is re-used; thus the time that would otherwise be spent recompiling the C++ code for the model can be saved.

data A named list or environment providing the data for the model, or a character vector for all the names of objects used as data. See the Note section below.

pars A vector of character strings specifying parameters of interest. The default is NA indicating all parameters in the model. If include = TRUE, only samples for parameters named in pars are stored in the fitted results. Conversely, if include = FALSE, samples for all parameters except those named in pars are stored in the fitted results.

chains A positive integer specifying the number of Markov chains. The default is 4.

iter A positive integer specifying the number of iterations for each chain (including warmup). The default is 2000.

warmup A positive integer specifying the number of warmup (aka burnin) iterations per chain. If step-size adaptation is on (which it is by default), this also controls the number of iterations for which adaptation is run (and hence these warmup samples should not be used for inference). The number of warmup iterations should not be larger than iter and the default is iter/2.

thin A positive integer specifying the period for saving samples. The default is 1, which is usually the recommended value.
init

Can be the digit 0, the strings "0" or "random", a function that returns a named list, or a list of named lists.

init="random" (default): Let Stan generate random initial values for all parameters. The seed of the random number generator used by Stan can be specified via the seed argument. If the seed for Stan is fixed, the same initial values are used. The default is to randomly generate initial values between −2 and 2 on the unconstrained support. The optional additional parameter init_r can be set to some value other than 2 to change the range of the randomly generated inits.

init="0", init=0: Initialize all parameters to zero on the unconstrained support.

inits via list: Set initial values by providing a list equal in length to the number of chains. The elements of this list should themselves be named lists, where each of these named lists has the name of a parameter and is used to specify the initial values for that parameter for the corresponding chain.

inits via function: Set initial values by providing a function that returns a list for specifying the initial values of parameters for a chain. The function can take an optional parameter chain_id through which the chain_id (if specified) or the integers from 1 to chains will be supplied to the function for generating initial values. See the Examples section below for examples of defining such functions and using a list of lists for specifying initial values.

When specifying initial values via a list or function, any parameters for which values are not specified will receive initial values generated as described in the init="random" description above.

seed

The seed for random number generation. The default is generated from 1 to the maximum integer supported by \( R \) on the machine. Even if multiple chains are used, only one seed is needed, with other chains having seeds derived from that of the first chain to avoid dependent samples. When a seed is specified by a number, as.integer will be applied to it. If as.integer produces NA, the seed is generated randomly. The seed can also be specified as a character string of digits, such as "12345", which is converted to integer.

algorithm

One of sampling algorithms that are implemented in Stan. Current options are "NUTS" (No-U-Turn sampler, Hoffman and Gelman 2011, Betancourt 2017), "HMC" (static HMC), or "Fixed_param". The default and preferred algorithm is "NUTS".

sample_file

An optional character string providing the name of a file. If specified the draws for all parameters and other saved quantities will be written to the file. If not provided, files are not created. When the folder specified is not writable, tempdir() is used. When there are multiple chains, an underscore and chain number are appended to the file name.

diagnostic_file

An optional character string providing the name of a file. If specified the diagnostics data for all parameters will be written to the file. If not provided, files are not created. When the folder specified is not writable, tempdir() is used. When there are multiple chains, an underscore and chain number are appended to the file name.
save_dso Logical, with default TRUE, indicating whether the dynamic shared object (DSO) compiled from the C++ code for the model will be saved or not. If TRUE, we can draw samples from the same model in another R session using the saved DSO (i.e., without compiling the C++ code again). This parameter only takes effect if fit is not used; with fit defined, the DSO from the previous run is used. When save_dso=TRUE, the fitted object can be loaded from what is saved previously and used for sampling, if the compiling is done on the same platform, that is, same operating system and same architecture (32bits or 64bits).

verbose TRUE or FALSE: flag indicating whether to print intermediate output from Stan on the console, which might be helpful for model debugging.

control A named list of parameters to control the sampler’s behavior. It defaults to NULL so all the default values are used. First, the following are adaptation parameters for sampling algorithms. These are parameters used in Stan with similar names here.

- `adapt_engaged` (logical)
- `adapt_gamma` (double, positive, defaults to 0.05)
- `adapt_delta` (double, between 0 and 1, defaults to 0.8)
- `adapt_kappa` (double, positive, defaults to 0.75)
- `adapt_t0` (double, positive, defaults to 10)
- `adapt_init_buffer` (integer, positive, defaults to 75)
- `adapt_term_buffer` (integer, positive, defaults to 50)
- `adapt_window` (integer, positive, defaults to 25)

In addition, algorithm HMC (called 'static HMC' in Stan) and NUTS share the following parameters:

- `stepsize` (double, positive)
- `stepsize_jitter` (double, [0,1])
- `metric` (string, one of "unit_e", "diag_e", "dense_e")

For algorithm HMC, we can also set

- `int_time` (double, positive)

For algorithm NUTS, we can set

- `max_treedepth` (integer, positive)

For test_grad mode, the following parameters can be set

- `epsilon` (double, defaults to 1e-6)
- `error` (double, defaults to 1e-6)

include Logical scalar defaulting to TRUE indicating whether to include or exclude the parameters given by the pars argument. If FALSE, only entire multidimensional parameters can be excluded, rather than particular elements of them.

cores Number of cores to use when executing the chains in parallel, which defaults to 1 but we recommend setting the mc.cores option to be as many processors as the hardware and RAM allow (up to the number of chains).

open_progress Logical scalar that only takes effect if cores > 1 but is recommended to be TRUE in interactive use so that the progress of the chains will be redirected to a file that is automatically opened for inspection. For very short runs, the user might prefer FALSE.
Other optional parameters:

- chain_id (integer)
- init_r (double, positive)
- test_grad (logical)
- append_samples (logical)
- refresh (integer)
- save_warmup (logical)
- deprecated: enable_random_init (logical)

chain_id can be a vector to specify the chain_id for all chains or an integer. For the former case, they should be unique. For the latter, the sequence of integers starting from the given chain_id are used for all chains.

init_r is used only for generating random initial values, specifically when init="random" or not all parameters are initialized in the user-supplied list or function. If specified, the initial values are simulated uniformly from interval [-init_r, init_r] rather than using the default interval (see the manual of (cmd)Stan).

test_grad (logical). If test_grad=TRUE, Stan will not do any sampling. Instead, the gradient calculation is tested and printed out and the fitted stanfit object is in test gradient mode. By default, it is FALSE.

append_samples (logical). Only relevant if sample_file is specified and is an existing file. In that case, setting append_samples=TRUE will append the samples to the existing file rather than overwriting the contents of the file.

refresh (integer) can be used to control how to indicate the progress during sampling (i.e. show the progress every refresh iterations). By default, refresh = max(iter/10, 1). The progress indicator is turned off if refresh <= 0.

Deprecated: enable_random_init (logical) being TRUE enables specifying initial values randomly when the initial values are not fully specified from the user.

save_warmup (logical) indicates whether to save draws during the warmup phase and defaults to TRUE. Some memory related problems can be avoided by setting it to FALSE, but some diagnostics are more limited if the warmup draws are not stored.

boost_lib The path for an alternative version of the Boost C++ to use instead of the one in the BH package.

eigen_lib The path for an alternative version of the Eigen C++ library to the one in RcppEigen.

Details

stan does all of the work of fitting a Stan model and returning the results as an instance of stanfit. First, it translates the Stan model to C++ code. Second, the C++ code is compiled into a binary shared object, which is loaded into the current R session (an object of S4 class stanmodel is created). Finally, samples are drawn and wrapped in an object of S4 class stanfit, which has methods such as print, summary, and plot to inspect and retrieve the results of the fitted model.

stan can also be used to sample again from a fitted model under different settings (e.g., different iter, data, etc.) by using the fit argument to specify an existing stanfit object. In this case, the compiled C++ code for the model is reused.
Value

An object of S4 class stanfit. However, if cores > 1 and there is an error for any of the chains, then the error(s) are printed. If all chains have errors and an error occurs before or during sampling, the returned object does not contain samples. But the compiled binary object for the model is still included, so we can reuse the returned object for another sampling.

Note

The data passed to stan are preprocessed before being passed to Stan. If data is not a character vector, the data block of the Stan program is parsed and R objects of the same name are searched starting from the calling environment. Then, if data is list-like but not a data.frame the elements of data take precedence. This behavior is similar to how a formula is evaluated by the lm function when data is supplied. In general, each R object being passed to Stan should be either a numeric vector (including the special case of a 'scalar') or a numeric array (matrix). The first exception is that an element can be a logical vector: TRUE’s are converted to 1 and FALSE’s to 0. An element can also be a data frame or a specially structured list (see details below), both of which will be converted into arrays in the preprocessing. Using a specially structured list is not encouraged though it might be convenient sometimes; and when in doubt, just use arrays.

This preprocessing for each element mainly includes the following:

1. Change the data of type from double to integer if no accuracy is lost. The main reason is that by default, R uses double as data type such as in a <- 3. But Stan will not read data of type int from real and it reads data from int if the data type is declared as real.
2. Check if there is NA in the data. Unlike BUGS, Stan does not allow missing data. Any NA values in supplied data will cause the function to stop and report an error.
3. Check data types. Stan allows only numeric data, that is, doubles, integers, and arrays of these. Data of other types (for example, characters and factors) are not passed to Stan.
4. Check whether there are objects in the data list with duplicated names. Duplicated names, if found, will cause the function to stop and report an error.
5. Check whether the names of objects in the data list are legal Stan names. If illegal names are found, it will stop and report an error. See (Cmd)Stan’s manual for the rules of variable names.
6. When an element is of type data.frame, it will be converted to matrix by function data.matrix.
7. When an element is of type list, it is supposed to make it easier to pass data for those declared in Stan code such as "vector[J] y1[I]" and "matrix[J,K] y2[I]". Using the latter as an example, we can use a list for y2 if the list has "I" elements, each of which is an array (matrix) of dimension "J*K". However, it is not possible to pass a list for data declared such as "vector[K] y3[I,J]"; the only way for it is to use an array with dimension "I*J*K". In addition, technically a data.frame in R is also a list, but it should not be used for the purpose here since a data.frame will be converted to a matrix as described above.

Stan treats a vector of length 1 in R as a scalar. So technically if, for example, "real y[1];" is defined in the data block, an array such as "y = array(1.0, dim = 1)" in R should be used. This is also the case for specifying initial values since the same underlying approach for reading data from R in Stan is used, in which vector of length 1 is treated as a scalar.
In general, the higher the optimization level is set, the faster the generated binary code for the model runs, which can be set in a Makevars file. However, the binary code generated for the model runs fast by using a higher optimization level at the cost of longer times to compile the C++ code.

References


See Also

`stanc` for translating model code in Stan modeling language to C++, `sampling` for sampling, and `stanfit` for the fitted results.

see `extract` and `as.array.stanfit` for extracting samples from `stanfit` objects.

Examples

```r
## Not run:
### example 1
library(rstan)
scode <- "
parameters {
  real y[2];
}
model {
  y[1] ~ normal(0, 1);
  y[2] ~ double_exponential(0, 2);
}
"
fit1 <- stan(model_code = scode, iter = 10, verbose = FALSE)
print(fit1)
fit2 <- stan(fit = fit1, iter = 10000, verbose = FALSE)

## extract samples as a list of arrays
e2 <- extract(fit2, permuted = TRUE)

## using as.array on the stanfit object to get samples
a2 <- as.array(fit2)

### example 2
### the result of this package is included in the package

excode <- '
  transformed data {
    real y[20];
    y[1] = 0.5796; y[2] = 0.2276; y[3] = -0.2959;
    y[10] = 0.3746; y[11] = 0.4773; y[12] = 0.1803;
  }
```

parameters {
  real mu;
  real<lower=0, upper=10> sigma;
  vector[2] z[3];
  real<lower=0> alpha;
}

model {
  y ~ normal(mu, sigma);
  for (i in 1:3)
    z[i] ~ normal(0, 1);
  alpha ~ exponential(2);
}

exfit <- stan(model_code = excode, save_dso = FALSE, iter = 500)
print(exfit)
plot(exfit)

## End(Not run)
## Not run:
## examples of specify argument `init` for function stan

## define a function to generate initial values that can
## be fed to function stan's argument `init`
# function form 1 without arguments
initf1 <- function() {
  list(mu = 1, sigma = 4, z = array(rnorm(6), dim = c(3,2)), alpha = 1)
}

# function form 2 with an argument named `chain_id`
initf2 <- function(chain_id = 1) {
  cat("chain_id =", chain_id, "n")
  list(mu = 1, sigma = 4, z = array(rnorm(6), dim = c(3,2)), alpha = chain_id)
}

# generate a list of lists to specify initial values
n_chains <- 4
init_ll <- lapply(1:n_chains, function(id) initf2(chain_id = id))

exfit0 <- stan(model_code = excode, init = initf1)
stan(fit = exfit0, init = initf2)
stan(fit = exfit0, init = init_ll, chains = n_chains)

## End(Not run)
Description

Translate a model specification in Stan code to C++ code, which can then be compiled and loaded for sampling.

Usage

```r
stanc(file, model_code = '', model_name = "anon_model", verbose = FALSE,
       obfuscate_model_name = TRUE, allow_undefined = FALSE,
       isystem = c(if (!missing(file)) dirname(file), getwd()))
```

Arguments

- **file**: A character string or a connection that \( \text{R} \) supports specifying the Stan model specification in Stan’s modeling language.
- **model_code**: Either a character string containing a Stan model specification or the name of a character string object in the workspace. This parameter is used only if parameter `file` is not specified, so it defaults to the empty string.
- **model_name**: A character string naming the model. The default is "anon_model". However, the model name will be derived from `file` or `model_code` (if `model_code` is the name of a character string object) if `model_name` is not specified.
- **verbose**: Logical, defaulting to `FALSE`. If `TRUE` more intermediate information is printed during the translation procedure.
- **obfuscate_model_name**: Logical, defaulting to `TRUE`, indicating whether to use a randomly-generated character string for the name of the C++ class. This prevents name clashes when compiling multiple models in the same R session.
- **isystem**: A character vector naming a path to look for file paths in `file` that are to be included within the Stan program named by `file`. See the Details section below.
- **allow_undefined**: A logical scalar defaulting to `FALSE` indicating whether to allow Stan functions to be declared but not defined in `file` or `model_code`. If `TRUE`, then it is the caller’s responsibility to provide a function definition in another header file or linked shared object.

Details

The `stanc_builder` function supports the standard C++ convention of specifying something like `#include "my_includes.txt"` on an entire line within the file named by the `file` argument. In other words, `stanc_builder` would look for "my_includes.txt" in (or under) the directories named by the isystem argument and — if found — insert its contents verbatim at that position before calling `stanc` on the resulting `model_code`. This mechanism reduces the need to copy common chunks of code across Stan programs. It is possible to include such files recursively.

Note that line numbers referred to in parser warnings or errors refer to the postprocessed Stan program rather than `file`. In the case of a parser error, the postprocessed Stan program will be
printed after the error message. Line numbers referred to in messages while Stan is executing also refer to the postprocessed Stan program which can be obtained by calling `get_stancode`.

**Value**

A list with named entries:

1. `model_name` Character string for the model name.
2. `model_code` Character string for the model’s Stan specification.
3. `cppcode` Character string for the model’s C++ code.
4. `status` Logical indicating success/failure (always TRUE) of translating the Stan code.

**Note**

Unlike R, in which variable identifiers may contain dots (e.g. a.1), Stan prohibits dots from occurring in variable identifiers. Furthermore, C++ reserved words and Stan reserved words may not be used for variable names; see the Stan User’s Guide for a complete list.

**References**


**See Also**

`stan_model` and `stan`

**Examples**

```r
stanmodelcode <- "
data {
  int<lower=0> N;
  real y[N];
}

parameters {
  real mu;
}

model {
  mu ~ normal(0, 10);
  y ~ normal(mu, 1);
}
"

r <- stanc(model_code = stanmodelcode, model_name = "normal1")
str(r)
```
Description

The components (slots) of a `stanfit` object and the various available methods are described below. When methods have their own more detailed documentation pages links are provided.

Objects from the Class

An object of class `stanfit` contains the output derived from fitting a Stan model as returned by the top-level function `stan` or the lower-level methods `sampling` and `vb` (which are defined on class `stanmodel`). Many methods (e.g., `print`, `plot`, `summary`) are provided for summarizing results and various access methods also allow the underlying data (e.g., simulations, diagnostics) contained in the object to be retrieved.

Slots

- `model_name`: The model name as a string.
- `model_pars`: A character vector of names of parameters (including transformed parameters and derived quantities).
- `par_dims`: A named list giving the dimensions for all parameters. The dimension for a scalar parameter is given as `numeric(0)`.
- `mode`: An integer indicating the mode of the fitted model. 0 indicates sampling mode, 1 indicates test gradient mode (no sampling is done), and 2 indicates error mode (an error occurred before sampling). Most methods for `stanfit` objects are useful only if `mode=0`.
- `sim`: A list containing simulation results including the posterior draws as well as various pieces of metadata used by many of the methods for `stanfit` objects.
- `inits`: The initial values (either user-specified or generated randomly) for all chains. This is a list with one component per chain. Each component is a named list containing the initial values for each parameter for the corresponding chain.
- `stan_args`: A list with one component per chain containing the arguments used for sampling (e.g. `iter`, `seed`, etc.).
- `stanmodel`: The instance of S4 class `stanmodel`.
- `date`: A string containing the date and time the object was created.
- `.MISC`: Miscellaneous helper information used for the fitted model. This is an object of type `environment`. Users rarely (if ever) need to access the contents of `.MISC`.

Methods

**Printing, plotting, and summarizing:**

- `show`: Print the default summary for the model.
- `print`: Print a customizable summary for the model. See `print.stanfit`. 
plot Create various plots summarizing the fitted model. See `plot.stanfit-method`.

summary Summarize the distributions of estimated parameters and derived quantities using the posterior draws. See `summary.stanfit-method`.

get_posterior_mean Get the posterior mean for parameters of interest (using `pars` to specify a subset of parameters). Returned is a matrix with one column per chain and an additional column for all chains combined.

Extracting posterior draws:

extract Extract the draws for all chains for all (or specified) parameters. See `extract`.

as.array, as.matrix, as.data.frame Coerce the draws (without warmup) to an array, matrix or data frame. See `as.array.stanfit`.

As.mcmc.list Convert a `stanfit` object to an `mcmc.list` as in package `coda`. See `As.mcmc.list`.

get_logposterior Get the log-posterior at each iteration. Each element of the returned list is the vector of log-posterior values (up to an additive constant, i.e. up to a multiplicative constant on the linear scale) for a single chain. The optional argument `inc_warmup` (defaulting to `TRUE`) indicates whether to include the warmup period.

Diagnostics, log probability, and gradients:

gen_sampler_params Obtain the parameters used for the sampler such as `stepsize` and `treedepth`. The results are returned as a list with one component (an array) per chain. The array has number of columns corresponding to the number of parameters used in the sampler and its column names provide the parameter names. Optional argument `inc_warmup` (defaulting to `TRUE`) indicates whether to include the warmup period.

gen_adaptation_info Obtain the adaptation information for the sampler if NUTS was used. The results are returned as a list, each element of which is a character string with the info for a single chain.

log_prob Compute the log probability density (lp__) for a set of parameter values (on the unconstrained space) up to an additive constant. The unconstrained parameters are specified using a numeric vector. The number of parameters on the unconstrained space can be obtained using method `get_num_upars`. A numeric value is returned. See also the documentation in `log_prob`.

grad_log_prob Compute the gradient of log probability density function for a set of parameter values (on the unconstrained space) up to an additive constant. The unconstrained parameters are specified using a numeric vector with the length being the number of unconstrained parameters. A numeric vector is returned with the length of the number of unconstrained parameters and an attribute named `log_prob` being the `lp__`. See also the documentation in `grad_log_prob`.

gen_num_upars Get the number of unconstrained parameters of the model. The number of parameters for a model is not necessarily equal to this number of unconstrained parameters. For example, when a parameter is specified as a simplex of length K, the number of unconstrained parameters is K-1.

unconstrain_pars Transform the parameters to unconstrained space. The input is a named list as for specifying initial values for each parameter. A numeric vector is returned. See also the documentation in `unconstrain_pars`.
constrain_pars  Get the parameter values from their unconstrained space. The input is a numeric vector. A list is returned. This function is contrary to unconstrain_pars. See also the documentation in constrain_pars.

Metadata and miscellaneous:

get_stancode  Get the Stan code for the fitted model as a string. The result can be printed in a readable format using cat.

get_stanmodel  Get the object of S4 class stanmodel of the fitted model.

get_elapsed_time  Get the warmup time and sample time in seconds. A matrix of two columns is returned with each row containing the warmup and sample times for one chain.

get_inits iter = NULL  Get the initial values for parameters used in sampling all chains. The returned object is a list with the same structure as the inits slot described above. If object@mode=2 (error mode) an empty list is returned. If iter is not NULL, then the draw from that iteration is returned for each chain rather than the initial state.

get_cpp_mode  Get the optimization mode used for compilation. The returned string is one of "fast", "presentation2", "presentation1", and "debug".

get_seed  Get the (P)RNG seed used. When the fitted object is empty (mode=2), NULL might be returned. In the case that the seeds for all chains are different, use get_seeds.

get_seeds  Get the seeds used for all chains. When the fitted object is empty (mode=2), NULL might be returned.

References


See Also

stan and stanmodel

Examples

## Not run:
showClass("stanfit")
ecode <- 
  parameters {
    real<lower=0> y[2];
  }
  model {
    y ~ exponential(1);
  }

fit <- stan(model_code = ecode, iter = 10, chains = 1)
fit2 <- stan(fit = fit)
print(fit2)
plot(fit2)
traceplot(fit2)
ainfo <- get_adaptation_info(fit2)
```r
stanfit-class

```
```
cat(ainfo[[1]])
seed <- get_seed(fit2)
sp <- get_sampler_params(fit2)
sp2 <- get_sampler_params(fit2, inc_warmup = FALSE)
head(sp[[1]])

lp <- log_prob(fit, c(1, 2))
grad <- grad_log_prob(fit, c(1, 2))
lpz <- attr(grad, "log_prob") # should be the same as "lp"

# get the number of parameters on the unconstrained space
n <- get_num_upars(fit)

# parameters on the positive real line (constrained space)
y1 <- list(y = rep(1, 2))

uy <- unconstrain_pars(fit, y1)
## uy should be c(0, 0) since here the log transformation is used
y1star <- constrain_pars(fit, uy)

print(y1)
print(y1star) # y1start should equal to y1

## End(Not run)

# Create a stanfit object from reading CSV files of samples (saved in rstan
# package) generated by function stan for demonstration purpose from model as follows.
#
excode <- 'transformed data {
  real y[20];
  y[1] <- 0.5796; y[2] <- 0.2276; y[3] <- -0.2959;
  y[16] <- 0.9459; y[17] <- -0.382; y[18] <- 0.7619;
  y[19] <- 1.0006; y[20] <- -1.7461;
}
parameters {
  real mu;
  real<lower=0, upper=10> sigma;
  vector[2] z[3];
  real<lower=0> alpha;
}
model {
  y ~ normal(mu, sigma);
  for (i in 1:3)
    z[i] ~ normal(0, 1);
  alpha ~ exponential(2);
}''
```
stanmodel-class

Class representing model compiled from C++

Description

A stanmodel object represents the model compiled from C++ code. The sampling method defined in this class may be used to draw samples from the model and optimizing method is for obtaining a point estimate by maximizing the log-posterior.

Objects from the Class

Instances of stanmodel are usually created by calling function stan_model or function stan.

Slots

model_name: The model name, an object of type character.

model_code: The Stan model specification, an object of type character.

model_cpp: Object of type list that includes the C++ code for the model.

mk_cppmodule: A function to return a RCpp module. This function will be called in function sampling and optimizing with one argument (the instance of stanmodel itself).

dso: Object of S4 class cxxdso. The container for the dynamic shared objects compiled from the C++ code of the model, returned from function cxxfunction in package inline.
Methods

- `show signature(object = "stanmodel"): print the Stan model specification.
- `vb signature(object = "stanmodel"): use the variational Bayes algorithms.
- `sampling signature(object = "stanmodel"): draw samples for the model (see sampling).
- `optimizing signature(object = "stanmodel"): obtain a point estimate by maximizing the posterior (see optimizing).
- `get_cxxflags signature(object = "stanmodel"): return the C++ code for the model as a character string. This is part of the C++ code that is compiled to the dynamic shared object for the model.
- `get_cxxflags signature(object = "stanmodel"): return the CXXFLAGS used for compiling the model. The returned string is like CXXFLAGS = -O3.

Note

Objects of class stanmodel can be saved for use across R sessions only if save_dso = TRUE is set during calling functions that create stanmodel objects (e.g., stan and stan_model).

Even if save_dso = TRUE, the model cannot be loaded on a platform (operating system, 32 bits or 64 bits, etc.) that differs from the one on which it was compiled.

See Also

- `stan_model, stanc, sampling, optimizing, vb

Examples

```r
showClass("stanmodel")
```

---

**stan_demo**  
**Demonstrate examples included in Stan**

Description

Stan includes a variety of examples and most of the BUGS example models that are translated into Stan modeling language. One example is chosen from a list created from matching user input and gets fitted in the demonstration.

Usage

```r
stan_demo(model = character(0),
          method = c("sampling", "optimizing", "meanfield", "fullrank"), ...)
```
Arguments

- **model**: A character string for model name to specify which model will be used for demonstration. The default is an empty string, which prompts the user to select one the available models. If `model = 0`, a character vector of all models is returned without any user intervention. If `model = i` where `i > 0`, then the ith available model is chosen without user intervention, which is useful for testing.

- **method**: Whether to call `sampling` (the default), `optimizing`, or one of the variants of `vb` for the demonstration.

- **...**: Further arguments passed to `method`.

Value

An S4 object of `stanfit`, unless `model = 0`, in which case a character vector of paths to available models is returned.

References


See Also

- `sampling`, `optimizing`

Examples

```r
## Not run:
dogsfit <- stan_demo("dogs") # run the dogs model
fit1 <- stan_demo(1) # run model_names[1]

## End(Not run)
```

---

**stan_model**

*Construct a Stan model*

Description

Construct an instance of S4 class `stanmodel` from a model specified in Stan’s modeling language. A `stanmodel` object can then be used to draw samples from the model. The Stan program (the model expressed in the Stan modeling language) is first translated to C++ code and then the C++ code for the model plus other auxiliary code is compiled into a dynamic shared object (DSO) and then loaded. The loaded DSO for the model can be executed to draw samples, allowing inference to be performed for the model and data.
stan_model

Usage

```
stan_model(file, model_name = "anon_model",
model_code = "", stanc_ret = NULL,
boost_lib = NULL, eigen_lib = NULL,
save_dso = TRUE, verbose = FALSE,
auto_write = rstan_options("auto_write"),
obfuscate_model_name = TRUE,
allow_undefined = FALSE, includes = NULL)
```

Arguments

file A character string or a connection that R supports specifying the Stan model
specification in Stan's modeling language.
model_name A character string naming the model; defaults to "anon_model". However, the
model name will be derived from file or model_code (if model_code is the
name of a character string object) if model_name is not specified.
model_code Either a character string containing the model specification or the name of a
character string object in the workspace. This is an alternative to specifying the
model via the file or stanc_ret arguments.
stanc_ret A named list returned from a previous call to the stanc function. The list can be
used to specify the model instead of using the file or model_code arguments.
boost_lib The path to a version of the Boost C++ library to use instead of the one in the
BH package.
eigen_lib The path to a version of the Eigen C++ library to use instead of the one in the
RcppEigen package.
save_dso Logical, defaulting to TRUE, indicating whether the dynamic shared object (DSO)
compiled from the C++ code for the model will be saved or not. If TRUE, we can
draw samples from the same model in another R session using the saved DSO
(i.e., without compiling the C++ code again).
verbose Logical, defaulting to FALSE, indicating whether to report additional intermediate
output to the console, which might be helpful for debugging.
auto_write Logical, defaulting to the value of rstan_options("auto_write"), indicating
whether to write the object to the hard disk using saveRDS. Although this argument
is FALSE by default, we recommend calling rstan_options("auto_write" = TRUE)
in order to avoid unnecessary recompilations. If file is supplied and its dirname
is writable, then the object will be written to that same directory, substituting a
.rds extension for the .stan extension. Otherwise, the object will be written to the
tempdir.
obfuscate_model_name A logical scalar that is TRUE by default and passed to stanc.
allow_undefined A logical scalar that is FALSE by default and passed to stanc.
includes If not NULL (the default), then a character vector of length one (possibly contain-
ing "\n") of the form "#include "/full/path/to/my_header.hpp"", which
will be inserted into the C++ code in the model's namespace and can be used
to provide definitions of functions that are declared but not defined in file or model_code when allow_undefined = TRUE

Details

If a previously compiled stanmodel exists on the hard drive, its validity is checked and then returned without recompiling. The most common form of invalidity seems to be Stan code that ends with a } rather than a blank line, which causes the hash checker to think that the current model is different than the one saved on the hard drive. To avoid reading previously compiled stanmodels from the hard drive, supply the stanc_ret argument rather than the file or model_code arguments.

There are three ways to specify the model’s code for stan_model:

1. parameter model_code: a character string containing the Stan model specification,
2. parameter file: a file name (or a connection) from which to read the Stan model specification, or
3. parameter stanc_ret: a list returned by stanc to be reused.

Value

An instance of S4 class stanmodel that can be passed to the sampling, optimizing, and vb functions.

References


See Also

stanmodel for details on the class.

sampling, optimizing, and vb, which take a stanmodel object as input, for estimating the model parameters.

More details on Stan, including the full user’s guide and reference manual, can be found at [http://mc-stan.org/](http://mc-stan.org/).

Examples

```r
## Not run:
stancode <- 'data {real y_mean;} parameters {real y;} model {y ~ normal(y_mean,1);}'
mod <- stan_model(model_code = stancode)
fit <- sampling(mod, data = list(y_mean = 0))
fit2 <- sampling(mod, data = list(y_mean = 5))

## End(Not run)
```
**Description**

This function takes a vector of names of \( \mathcal{R} \) objects and outputs text representations of the objects to a file or connection. The file created by `stan_rdump` is typically used as data input of the Stan package \( \text{(http://mc-stan.org/)} \) or `sourced` into another \( \mathcal{R} \) session. The usage of this function is very similar to `dump` in \( \mathcal{R} \).

**Usage**

```r
stan_rdump(list, file = "", append = FALSE,
           envir = parent.frame(),
           width = options("width")$width,
           quiet = FALSE)
```

**Arguments**

- `list` A vector of character string: the names of one or more \( \mathcal{R} \) objects to be dumped. See the note below.
- `file` Either a character string naming a file or a `connection`. "" indicates output to the console.
- `append` Logical: if TRUE and file is a character string, output will be appended to file; otherwise, it will overwrite the contents of file.
- `envir` The environment to search for objects.
- `width` The width for maximum characters on a line. The output is broken into lines with width.
- `quiet` Whether to suppress warning messages that would appear when a variable is not found or not supported for dumping (not being numeric or it would not be converted to numeric) or a variable name is not allowed in Stan.

**Value**

An invisible character vector containing the names of the objects that were dumped.

**Note**

`stan_rdump` only dumps numeric data, which first can be a scalar, vector, matrix, or (multidimensional) array. Additional types supported are `logical` (TRUE and FALSE), `factor`, `data.frame` and a specially structured list.

The conversion for logical variables is to map TRUE to 1 and FALSE to 0. For factor variable, function `as.integer` is used to do the conversion (If we want to transform a factor \( f \) to approximately its original numeric values, see the help of function `factor` and do the transformation before calling `stan_rdump`). In the case of `data.frame`, function `data.matrix` is applied to the data frame before
dUMPING. See the notes in stan for the specially structured list, which will be converted to array before dumping.

stan_rdump will check whether the names of objects are legal variable names in Stan. If an illegal name is found, data will be dumped with a warning. However, passing the name checking does not necessarily mean that the name is legal. More details regarding rules of variable names in Stan can be found in Stan's manual.

If objects with specified names are not found, a warning will be issued.

References


See Also
dump

Examples

# set variables in global environment
a <- 17.5
b <- c(1,2,3)
# write variables a and b to file ab.data.R in working directory
stan_rdump(c('a','b'), "ab.data.R")

x <- 1; y <- 1:10; z <- array(1:10, dim = c(2,5))
stan_rdump(ls(pattern = "^[xyz]"), "xyz.Rdump")
cat(paste(readLines("xyz.Rdump"), collapse = '\n'), '\n')
unlink("xyz.Rdump")

stan_version

Obtain the version of Stan

Description

The stan version is in form of major.minor.patch; the first version is 1.0.0, indicating major version 1, minor version 0 and patch level 0. Functionality only changes with minor versions and backward compatibility will only be affected by major versions.

Usage

stan_version()

Value

A character string giving the version of Stan used in this version of RStan.
summary-methods

References


See Also

`stan` and `stan_model`

Examples

```r
stan_version()
```

---

**Summary method for stanfit objects**

**Description**

Summarize the distributions of estimated parameters and derived quantities using the posterior draws.

**Usage**

```r
## S4 method for signature 'stanfit'
summary(object, pars, probs = c(0.025, 0.25, 0.50, 0.75, 0.975),
         use_cache = TRUE, ...)
```

**Arguments**

- `object` An instance of class `stanfit`.
- `pars` A character vector of parameter names. Defaults to all parameters as well as the log-posterior (`lp__`).
- `probs` A numeric vector of quantiles of interest. The default is `c(0.025, 0.25, 0.5, 0.75, 0.975)`.
- `use_cache` Logical, defaulting to `TRUE`. When `use_cache=TRUE` the summary quantities for all parameters are computed and cached for future use. Setting `use_cache=FALSE` can be used to avoid performing the summary computations for all parameters if `pars` is given as some specific parameters.
- `...` Currently unused.

**Value**

The summary method returns a named list with elements `summary` and `c_summary`, which contain summaries for for all chains merged and individual chains, respectively. Included in the summaries are quantiles, means, standard deviations (sd), effective sample sizes (n_eff), and split Rhats (the potential scale reduction derived from all chains after splitting each chain in half and treating the halves as chains). For the summary of all chains merged, Monte Carlo standard errors (`se_mean`) are also reported.
See Also

`monitor`, which computes similar summaries but accepts an array of MCMC draws as its input rather than a `stanfit` object.

Examples

```r
## Not run:
ecode <- 'parameters {
  real<lower=0> y[2];
}
model {
  y ~ exponential();
}
fit <- stan(model_code = ecode)
s <- summary(fit, probs = c(0.1, 0.9))
s$s_summary # all chains merged
s$c_summary # individual chains
## End(Not run)
```

traceplot Markov chain traceplots

Description

Draw the traceplot corresponding to one or more Markov chains, providing a visual way to inspect sampling behavior and assess mixing across chains and convergence.

Usage

```r
## S4 method for signature 'stanfit'
traceplot(object, pars, include = TRUE, unconstrain = FALSE,
  inc_warmup = FALSE, window = NULL, nrow = NULL, ncol = NULL, ...)```

Arguments

- `object`: An instance of class `stanfit`.
- `pars`: A character vector of parameter names. Defaults to all parameters or the first 10 parameters (if there are more than 10).
- `include`: Should the parameters given by the `pars` argument be included (the default) or excluded from the plot? Only relevant if `pars` is not missing.
- `inc_warmup`: TRUE or FALSE, indicating whether the warmup sample are included in the trace plot; defaults to FALSE.
window A vector of length 2. Iterations between \texttt{window[1]} and \texttt{window[2]} will be shown in the plot. The default is to show all iterations if \texttt{inc\_warmup} is \texttt{TRUE} and all iterations from the sampling period only if \texttt{inc\_warmup} is \texttt{FALSE}. If \texttt{inc\_warmup} is \texttt{FALSE} the iterations specified in \texttt{window} should not include iterations from the warmup period.

unconstrain Should parameters be plotted on the unconstrained space? Defaults to \texttt{FALSE}.

\texttt{nrow,ncol} Passed to \texttt{facet\_wrap}.

\texttt{...} Optional arguments to pass to \texttt{geom\_path} (e.g. size, linetype, alpha, etc.).

Value

A \texttt{ggplot} object that can be further customized using the \texttt{ggplot2} package.

Methods

\texttt{traceplot} signature(object = "stanfit")Plot the sampling paths for all chains.

See Also

List of RStan plotting functions, Plot options

Examples

```r
## Not run:
# Create a stanfit object from reading CSV files of samples (saved in rstan
# package) generated by function stan for demonstration purpose from model as follows.
# excode <- '
transformed data {
  real y[20];
  y[1] <- 0.5796; y[2] <- 0.2276; y[3] <- -0.2959;
  y[16] <- 0.9459; y[17] <- -0.382; y[18] <- 0.7619;
  y[19] <- 0.1006; y[20] <- -1.7461;
}
parameters {
  real mu;
  real<lower=0, upper=10> sigma;
  vector[2] z[3];
  real<lower=0> alpha;
}
model {
  y ~ normal(mu, sigma);
  for (i in 1:3)
    z[i] ~ normal(0, 1);
  alpha ~ exponential(2);
}
```
Run Stan's variational algorithm for approximate posterior sampling

### Description

Approximately draw from a posterior distribution using variational inference. We recommend calling `stan` or `sampling` for final inferences and only using `vb` to get a rough idea of the parameter distributions.

### Usage

```r
# S4 method for signature 'stanmodel'
vb(object, data = list(), pars = NA, include = TRUE, 
    seed = sample.int(.Machine$integer.max, 1), 
    init = 'random', check_data = TRUE, 
    sample_file = tempfile(fileext = '.csv'), 
    algorithm = c("meanfield", "fullrank"), ...)
```

### Arguments

- **object**: An object of class `stanmodel`.
- **data**: A named list or environment providing the data for the model or a character vector for all the names of objects used as data. See the Note section in `stan`.
- **pars**: If not `NA`, then a character vector naming parameters, which are included in the output if `include = TRUE` and excluded if `include = FALSE`. By default, all parameters are included.
- **include**: Logical scalar defaulting to `TRUE` indicating whether to include or exclude the parameters given by the `pars` argument. If `FALSE`, only entire multidimensional parameters can be excluded, rather than particular elements of them.
seed  
The seed for random number generation. The default is generated from 1 to the maximum integer supported by R on the machine. Even if multiple chains are used, only one seed is needed, with other chains having seeds derived from that of the first chain to avoid dependent samples. When a seed is specified by a number, as.integer will be applied to it. If as.integer produces NA, the seed is generated randomly. The seed can also be specified as a character string of digits, such as "12345", which is converted to integer.

init  
Initial values specification. See the detailed documentation for the init argument in stan.

check_data  
Logical, defaulting to TRUE. If TRUE the data will be preprocessed; otherwise not. See the Note section in stan.

sample_file  
A character string of file name for specifying where to write samples for all parameters and other saved quantities. This defaults to a temporary file.

algorithm  
Either "meanfield" (the default) or "fullrank", indicating which variational inference algorithm is used. The "meanfield" option uses a fully factorized Gaussian for the approximation whereas the fullrank option uses a Gaussian with a full-rank covariance matrix for the approximation. Details and additional references are available in the Stan manual.

...  
Other optional parameters:

• iter (positive integer), the maximum number of iterations, defaulting to 10000.
• grad_samples (positive integer), the number of samples for Monte Carlo estimate of gradients, defaulting to 1.
• elbo_samples (positive integer), the number of samples for Monte Carlo estimate of ELBO (objective function), defaulting to 100. (ELBO stands for "the evidence lower bound".)
• eta (double), positive stepsize weighting parameter for variational inference but is ignored if adaptation is engaged, which is the case by default.
• adapt_engaged (logical), a flag indicating whether to automatically adapt the stepsize, defaulting to TRUE.
• tol_rel_obj (positive double), the convergence tolerance on the relative norm of the objective, defaulting to 0.01.
• eval_elbo (positive integer), evaluate ELBO every Nth iteration, defaulting to 100.
• output_samples (positive integer), number of posterior samples to draw and save, defaults to 1000.
• adapt_iter (positive integer), the maximum number of iterations to adapt the stepsize, defaulting to 50. Ignored if adapt_engaged = FALSE.

Refer to the manuals for both CmdStan and Stan for more details.

Value  
An object of stanfit-class.
Methods

```r
vb signature(object = "stanmodel")
```

Call Stan’s variational Bayes methods for the model defined by S4 class `stanmodel` given the data, initial values, etc.

References


See Also

`stanmodel`

The manuals of CmdStan and Stan.

Examples

```r
## Not run:
m <- stan_model(model_code = 'parameters {real y;} model {y ~ normal(0,1);}')
f <- vb(m)

## End(Not run)
```
Index

*Topic **classes**
  stanfit-class, 48
  stanmodel-class, 52

*Topic **methods**
  extract, 10
  plot-methods, 24
  summary-methods, 59
  traceplot, 60

*Topic **package**
  rstan-package, 3

*Topic **rstan**
  makeconf_path, 17
  read_rdump, 29
  rstan-package, 3
  rstan_options, 32
  stan, 38
  stan_model, 54
  stan_rdump, 57
  stan_version, 58

arrangeGrob, 7
as.array, 5
as.array.stanfit, 11, 44, 49
as.data.frame.stanfit(as.array), 5
as.matrix.stanfit(as.array), 5
As.mcmc.list, 6, 49

bayesplot-package, 3

cat, 50
connection, 57
constrain_pars, 50
constrain_pars.log_prob-methods, 14
constrain_pars.stanfit-method
(log_prob-methods), 14

data.frame, 17
Diagnostic plots, 7
dim.stanfit(as.array), 5
dimnames.stanfit(as.array), 5

dimname, 55
double, 9
dump, 29, 58

expose_stan_functions, 9
extract, 5, 6, 10, 22, 23, 44, 49
extract.stanfit-method(extract), 10
extract_sparse_parts, 13

facet_wrap, 25, 61
formals, 9

gem_path, 26, 61
get_adaptation_info.stanfit-class, 48
get_adaptation_info.stanfit-method
(stanfit-class), 48
get_cppcode.stanmodel-class, 52
get_cppcode.stanmodel-method
(stanmodel-class), 52
get_cpp_mode.stanfit-class, 48
get_cpp_mode.stanfit-method
(stanfit-class), 48
get_cxxflags.stanmodel-class, 52
get_cxxflags.stanmodel-method
(stanmodel-class), 52
get_elapsed_time.stanfit-class, 48
get_elapsed_time.stanfit-method
(stanfit-class), 48
get_inits.stanfit-class, 48
get_inits.stanfit-method
(stanfit-class), 48
get_logposterior, 22, 23
get_logposterior.stanfit-class, 48
get_logposterior.stanfit-method
(stanfit-class), 48
get_num_upars.log_prob-methods, 14
get_num_upars.stanfit-method
(log_prob-methods), 14
get_posterior_mean.stanfit-class, 48
<table>
<thead>
<tr>
<th>Function</th>
<th>Page(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>get_posterior_mean</td>
<td>48</td>
</tr>
<tr>
<td>get_sampler_params</td>
<td>22, 23</td>
</tr>
<tr>
<td>get_sampler_params</td>
<td>48</td>
</tr>
<tr>
<td>get_sampler_params, stanfit, logical-method</td>
<td>48</td>
</tr>
<tr>
<td>get_seed</td>
<td>48</td>
</tr>
<tr>
<td>get_seed, stanfit-method</td>
<td>48</td>
</tr>
<tr>
<td>get_seeds</td>
<td>48</td>
</tr>
<tr>
<td>get_seeds, stanfit-method</td>
<td>48</td>
</tr>
<tr>
<td>get_stancode</td>
<td>47</td>
</tr>
<tr>
<td>get_stancode</td>
<td>48</td>
</tr>
<tr>
<td>get_stanmodel</td>
<td>48</td>
</tr>
<tr>
<td>get_stanmodel, stanfit-method</td>
<td>48</td>
</tr>
<tr>
<td>ggplot</td>
<td>24, 26, 61</td>
</tr>
<tr>
<td>grad_log_prob</td>
<td>49</td>
</tr>
<tr>
<td>grad_log_prob, log_prob-methods</td>
<td>14</td>
</tr>
<tr>
<td>grad_log_prob, stanfit-method</td>
<td>14</td>
</tr>
<tr>
<td>is.array.stanfit (as.array)</td>
<td>5</td>
</tr>
<tr>
<td>lm</td>
<td>43</td>
</tr>
<tr>
<td>log_prob</td>
<td>49</td>
</tr>
<tr>
<td>log_prob, log_prob-methods</td>
<td>14</td>
</tr>
<tr>
<td>log_prob, stanfit-method</td>
<td>14</td>
</tr>
<tr>
<td>log_prob-methods</td>
<td>14</td>
</tr>
<tr>
<td>loo-package</td>
<td>3</td>
</tr>
<tr>
<td>makeconf_path</td>
<td>17</td>
</tr>
<tr>
<td>Matrix</td>
<td>13</td>
</tr>
<tr>
<td>matrix</td>
<td>13</td>
</tr>
<tr>
<td>mcmc.list</td>
<td>6, 7, 49</td>
</tr>
<tr>
<td>monitor</td>
<td>11, 18, 60</td>
</tr>
<tr>
<td>names.stanfit (as.array)</td>
<td>5</td>
</tr>
<tr>
<td>names&lt;-stanfit (as.array)</td>
<td>5</td>
</tr>
<tr>
<td>optimizing</td>
<td>19, 53, 54, 56</td>
</tr>
<tr>
<td>optimizing, stanmodel-method</td>
<td>19</td>
</tr>
<tr>
<td>pairs</td>
<td>22, 23</td>
</tr>
<tr>
<td>plots.stanfit, missing-method</td>
<td>24</td>
</tr>
<tr>
<td>plot, stanfit-method</td>
<td>24</td>
</tr>
<tr>
<td>plot-methods</td>
<td>24</td>
</tr>
<tr>
<td>Plots</td>
<td>25</td>
</tr>
<tr>
<td>points</td>
<td>23</td>
</tr>
<tr>
<td>print</td>
<td>19, 28</td>
</tr>
<tr>
<td>quantile</td>
<td>59</td>
</tr>
<tr>
<td>quietgg (Plots)</td>
<td>25</td>
</tr>
<tr>
<td>read_rdump</td>
<td>29</td>
</tr>
<tr>
<td>read_stan_csv</td>
<td>30</td>
</tr>
<tr>
<td>regexp</td>
<td>17</td>
</tr>
<tr>
<td>rstan (rstan-package)</td>
<td>3</td>
</tr>
<tr>
<td>rstan-package</td>
<td>3</td>
</tr>
<tr>
<td>rstanplotting-functions</td>
<td>31</td>
</tr>
<tr>
<td>rstan.package.skeleton</td>
<td>31</td>
</tr>
<tr>
<td>rstan_gg_options</td>
<td>32</td>
</tr>
<tr>
<td>rstan_ggtheme_options</td>
<td>32</td>
</tr>
<tr>
<td>rstan_ggtheme_options (rstan_gg_options)</td>
<td>32</td>
</tr>
<tr>
<td>rstan_options</td>
<td>32</td>
</tr>
<tr>
<td>rstanarm-package</td>
<td>3</td>
</tr>
<tr>
<td>rstantools-package</td>
<td>3</td>
</tr>
<tr>
<td>sampling</td>
<td>33, 37, 44, 48, 53, 54, 56, 62</td>
</tr>
<tr>
<td>sampling, stanmodel-method (sampling)</td>
<td>33</td>
</tr>
<tr>
<td>saveRDS</td>
<td>55</td>
</tr>
<tr>
<td>set_cppo</td>
<td>36</td>
</tr>
<tr>
<td>sfList2stanfit</td>
<td>36</td>
</tr>
<tr>
<td>shinystan-package</td>
<td>3</td>
</tr>
<tr>
<td>show, stanfit-method (stanfit-class)</td>
<td>48</td>
</tr>
<tr>
<td>show, stanmodel-method</td>
<td>52</td>
</tr>
<tr>
<td>smoothScatter</td>
<td>23</td>
</tr>
<tr>
<td>source</td>
<td>57</td>
</tr>
<tr>
<td>sourceCpp</td>
<td>9, 10</td>
</tr>
<tr>
<td>stan</td>
<td>4, 18, 20, 34–37, 38, 47, 48, 50, 58, 59, 62, 63</td>
</tr>
<tr>
<td>stan_ac</td>
<td>31</td>
</tr>
<tr>
<td>stan_ac (Plots)</td>
<td>25</td>
</tr>
<tr>
<td>stan_demo</td>
<td>53</td>
</tr>
<tr>
<td>stan_dens</td>
<td>31</td>
</tr>
<tr>
<td>stan_dens (Plots)</td>
<td>25</td>
</tr>
<tr>
<td>stan_diag</td>
<td>31</td>
</tr>
<tr>
<td>stan_diag (Diagnostic plots)</td>
<td>7</td>
</tr>
</tbody>
</table>
stan_ess, 31
stan_ess (Diagnostic plots), 7
stan_hist, 31
stan_hist (Plots), 25
stan_mcse, 31
stan_mcse (Diagnostic plots), 7
stan_model, 47, 53, 54, 59
stan_par (Diagnostic plots), 7
stan_plot, 24, 31
stan_plot (Plots), 25
stan_rdump, 29, 57
stan_rhat, 31
stan_rhat (Diagnostic plots), 7
stan_scat, 31
stan_scat (Plots), 25
stan_trace, 31
stan_trace (Plots), 25
stan_version, 58
stanc, 9, 44, 45, 53, 55
stanc_builder (stanc), 45
stanfit, 4–6, 9–11, 14, 16, 19, 23, 24, 29, 30,
33, 35, 43, 44, 59, 60
stanfit (stanfit-class), 48
stanfit-class, 48
stanmodel, 9, 20, 21, 34, 35, 48, 50, 56, 62, 64
stanmodel-class, 52
stat_bin, 7
summary, 29
summary, stanfit-method
(summary-methods), 59
summary-methods, 59
tempdir, 55
theme, 32
traceplot, 26, 60
traceplot, stanfit-method (traceplot), 60
unconstrain_pars, 49
unconstrain_pars (log_prob-methods), 14
unconstrain_pars, stanfit-method
(log_prob-methods), 14
vb, 48, 53, 54, 56, 62
vb, stanmodel-method (vb), 62
View, 17